Assessment of Integrated Simulation in Energy Performance Directive

A thesis submitted for the degree of Master of Science

Energy Systems and the Environment

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Abstract

The purpose of this project is to examine and discuss the implications of the new Directive of the European Union on the Energy Performance of Buildings and to then introduce the concept of using integrated energy simulation tools as a way to assess the requirements of this Directive.

A general background review and a description of the Directive's proposals are undertaken in the first chapters. The key point made is that the method of implementing this Directive is not yet specified. This thesis establishes a methodology that could integrate all aspects of the required calculations for the energy performance of buildings. In addition, the project examines whether or not integrated simulation tools can deal well enough with the complexity of integrating all of a building's energy performance aspects to answer the requirements of the Directive.

A case study building was modelled using the ESP-r simulation program in order to examine the way in which different energy performance aspects (i.e. thermal insulation, heating, orientation) are dealt with, combined and integrated by this program. Results for different constructions U values, heating control strategies, climate conditions, building orientation, occupancy levels and air tightness of the building were produced by ESP-r. Moreover, a comfort analysis for the occupants of the building was also undertaken for each change.

Finally, the thesis briefly describes the potential benefits of providing a building energy and environmental overview in the form of an Integrated Performance View (IPV), containing and presenting concisely (e.g. by using graphs) all of the information relating to the energy performance aspects of a building model, with regard to addressing the requirements of the Directive.

Contents

1 Introduction

1.1 Energy and buildings

Present day buildings tend to be energy dependent to such a degree that without energy they could not be operated or inhabited. Energy in buildings is primarily used for lighting, heating, ventilating and cooling. Secondary uses include domestic hot water, vertical transportation, etc. The amount of energy actually consumed depends on the design of the building, its systems and how they are operated. However, according to the European Commission's figures[1] & [2], 40.7% of total energy demand is used in the residential and tertiary* sectors, with the majority of such energy consumption being building-related. Space heating is by far the largest energy end-use of households in Member States (57%), followed by water heating (25%). Electrical appliances and lighting make up 11% of this sector's total energy consumption. For the tertiary sector the energy consumption for space heating is lower than the household consumption (52% of the total sector's energy consumption), while lighting and office equipment plus "others" stand at 14% and 16% respectively. Approximately 10% of the consumed energy in buildings comes from renewable energy sources. Thus, energy use in buildings is a major contributor to fossil fuel use and carbon dioxide production.

In relation to energy that is used in buildings for heating, hot water, air-conditioning or lighting purposes, the European Commission estimates that a potential saving of around 22% of present consumption could be fully realised by the year 2010 by implementing energy efficiency and energy conservation measures in new and existing buildings[1] & [2]. These measures will make necessary the construction of buildings with better energy design and performance and the use of high efficiency electrical, heating and equipment generally. This figure has been based on the assumption of a normal rate of retrofitting and rehabilitation for existing buildings, a net increase in the building stock of around 1.5% per year, and a successively increasing share in the use of best available technologies in buildings[3].

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* Tertiary: includes offices, wholesale and retail trade, hotels, restaurants, schools, hospitals, sports halls, etc. but excludes industrial buildings

1.2 *Improving the energy performance of buildings*

1.2.1 Energy performance in buildings

According to the European Commission's definition[2], the energy performance of a building can be defined as *"the total energy efficiency of a building, reflected in one or more numeric indicators which have been calculated, taking into account insulation, installation characteristics, design and positioning, own energy generation and other factors that influence the net energy demand"*.

1.2.2 Climate, Sustainability and Global Warming – Background issues relating to living on earth

Climate has played a dominant role in shaping human culture and the structure of civilization over the last several thousands years. As the glaciers of the last ice age retreated, the climate became suitable for the domestication of a small number of plants and animals. The Neolithic times marked the birth of agriculture, and the construction of permanent settlements. These settlements in turn either joined together or were conquered to form kingdoms and empires. The ability of ever-growing human populations to survive has depended upon a relatively benign climate that has a sufficiently long growing season and adequate precipitation. Likewise, the manner in which appropriate shelter is constructed and most commerce and trade is conducted depends upon a predictable and relatively stable climate. The industrial revolution insulated some aspects of human activity from the vagaries of the weather but climate still plays a significant role the form taken by the infrastructure of cities, transport systems and power generation. If the climate is not stable, highly variable or subject to wild swings in precipitation, drought or storms, people and economies can become vulnerable.

The principle embodied in sustainability is that the current generation should meet its own needs without compromising the ability of future generations to meet theirs. A drastically or irreversibly altered climate system has the potential to compromise the ability of future generations to meet their needs if, for example the climate system changes so much that people would find it more difficult to grow food, protect themselves from weather related events, or if they suffer more severe pollution, diseases or pest infestations. Future generations could also be impoverished if there is a significant decline in the number of species or the population of plants and animals that survive under an altered climate system, in other words, if the balance is upset. An additional equity issue is that the people who are most vulnerable to these changes are those who are poorer, and who depend upon the reliable weather and environmental conditions to provide goods and services such as food and shelter. While subsistence farmers, fishers and forest dwellers might suffer the greatest consequences of climate change, they will probably have contributed little to causing those changes. Adverse climate consequences are also likely to more severely affect people in developing countries.

However, the threat of changes in the Earth's climate exists today and the most publicised risk is that of global warming. The Earth's temperature is approximately 33^{o}C warmer than it would be naturally because there are trace gases in the atmosphere that trap radiant heat from escaping back into space (Figure 1). However, human activities, and additionally, the release of industrial gases are increasing the concentration in the atmosphere of all the natural greenhouse gases (water vapour, carbon dioxide, carbon monoxide, CFC's, methane, etc.), which have until now provided earth dwellers with a much needed "heat trap". This increase in concentration is now equivalent to approximately 0.7% of the solar energy reaching the Earth's surface. The rise in the Earth's average temperature since 1861 is estimated to be 0.6 $\pm$ 0.2^{o}C and according to Dr Moomaw[4] from the Fletcher School of Law and Diplomacy at the Tufts University in USA, lies outside the range of normal variance in the climate record for the past 1000 years. The twentieth century and in particular the decade of the 1990s are the warmest during the last millennium. Moreover, 1998 is the warmest recorded single year recorded since records were kept, at around 1.1^{o}C warmer than the average expected temperature extrapolated over the 900 years prior to 1900. In addition to the effect on general weather, many other consequences of global warming and climate change have been measured including lengthened growing seasons in northern latitudes, thinning arctic ice sheets, retreating glaciers, declining coral reefs, rising sea level increased precipitation and droughts, and altered migration patterns of birds and mammals.

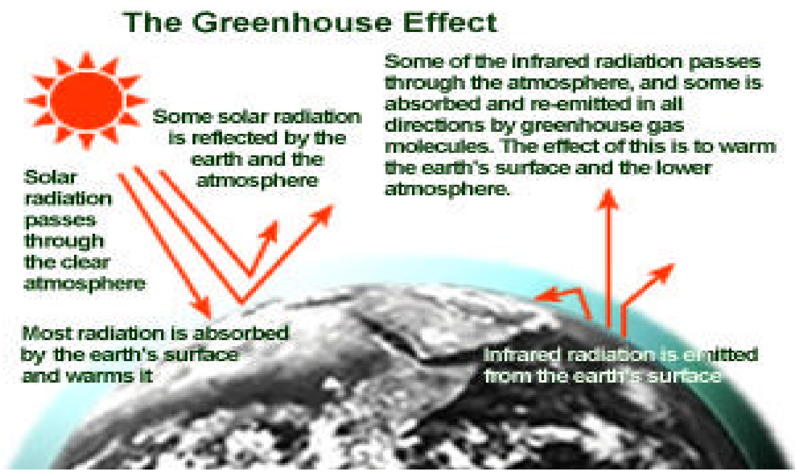


Figure 1

1.2.3 Why set standards to calculate the energy performance of buildings?

It has been found that one of the most significant contributors to the production of the greenhouse gases is the consumption of fossil fuels. Carbon dioxide is one of the basic greenhouse gases and globally, buildings account for 31.5% of energy related carbon dioxide emissions. It is estimated by the Intergovernmental Panel on Climate Change (IPCC) that cost effective energy conservation measures could be effected in the energy sector by using available technology that would lower carbon dioxide emissions by 27% by 2010, 31% by 2020 and 52% by 2050[4]. However, even to achieve such cost effective goals would require international government agreements and an associated policy on energy conservation. Within this, it is generally accepted that a major contribution could be made by the introduction of a set of specific measurements and checks for the energy performance of buildings. Following uncertainties in energy supply and concern over the risk of global warming, many countries have now introduced target values for reducing energy consumption in buildings. Overall, these are aimed at reducing energy consumption by between 15-30%[5]. But as yet no set structure has been agreed to put such a scheme into effect.

Assessment of energy performance is important at all stages in the life of a building: at the design stage, during construction and throughout the life of the building. A great deal of energy can be saved during the construction of new buildings and even more so in the renovation of existing buildings. If the conservation of energy is considered in the early stages of design, much can be achieved at low cost. In the past, housing developments for example, in Milton Keynes in UK[6], have shown that it is possible at little additional cost to reduce heating costs to between two-thirds and one half of those in otherwise equivalent houses by incorporating higher insulation standards than are currently required by Building Regulations, and to one third by conscientiously adopting an energy-saving approach to design. The additional building costs can be recovered by savings on energy bills within five to seven years[6]. Such assessments may be used as a measure of the relative energy performance of the building stock of nations or simply as a yardstick for comparing two buildings containing similar activity systems. Energy performance criteria may also be used to check design predictions or as a basis for relevant standards. This is regarded as a key issue with regard to the development of this thesis.

2 Directive of the European Parliament and of the council on the energy performance of buildings

2.1 Indroduction to the Directive

Considering that residential and tertiary buildings account for more than 40% of final energy consumption in the European Community[7], the European Commission took the initiative on 11/05/2001 of proposing a Directive aimed at promoting the improvement of the energy performance of new and existing buildings in all EU Member States. A key feature of the Directive is in ensuring as much as possible that only such measures as are the most cost-effective are undertaken. This proposal is a follow-up to earlier Directives relating to building energy efficiency on boilers (92/42/EEC), construction products (89/106/EEC) and SAVE programme provisions on buildings. And although there is already a Directive on the energy certification of buildings (Directive 93/76/EEC), this was adopted in a different political context: having been agreed before the Kyoto agreement and before the uncertainties that recently have been raised in connection with the security of energy supply in the Union, thus it may have similar, but does not have the same objectives as this Directive. The latest document outlines an additional instrument, that is, putting the subject of energy performance into the context of new challenges and proposing more concrete action to fill any gaps. It is the first time that the European Commission has stated the need to *prove the integrated* energy performance of buildings. This new Directive gives practical expression to the priorities set up in the Green Paper[8] on the security of Energy Supply with regard to energy efficiency and renewable energy. Firstly, it recognises that the European Community is increasingly dependent on external energy sources and secondly, that greenhouse gas emissions are on the increase. The European Community can have only limited influence on the energy supply but can influence energy demand. One possible solution to both of the afore-stated problems of limited energy resource and gaseous emissions is to reduce energy consumption by improving energy efficiency and by implementing low energy design strategies.

However, given the low turnover rate of buildings (their typical lifetime being 50 to 100 years), the European Commission has included in its proposal certain measures that also target the existing stock of buildings, which comprises the largest potential for improving energy performance in the short and medium terms. The proposed Directive lays down a framework that will lead to increased coordination between Member States with regard to legislation in this field, and covers the building envelope and installed equipment such as heating, air-conditioning and ventilation. It does not cover measures for non-installed equipment such as domestic appliances (including kitchen appliances), which together are responsible for 18% of the total energy consumption in the residential sector.

2.2 Main Elements

In this thesis it is proposed to outline the main elements of the Directive in general and then to examine key aspects of these in detail. The four main elements are:

A) Establishment of a general framework of a common methodology for calculating the integrated energy performance of buildings (Articles 1 and 3). This approach is already being applied both in EU Member States such as Germany, France, the UK, Italy and the Netherlands and outside the EU (in the US, Australia, Canada and New Zealand, for instance). However, the Directive now proposes a single common methodology that would facilitate the comparison of buildings throughout the EU for prospective users and that would form a basis for the adoption of integrated minimum energy performance standards for different building categories, reflecting local circumstances and particularly taking into account climatic differences.

B) Application of minimum standards of energy performance to new buildings and to certain existing buildings when they are renovated (Articles 4 and 5). Under the European Commission's proposal, new residential buildings and dwellings as well as new buildings in the tertiary sector should meet the minimum energy performance standards based on an integrated methodology. Furthermore these standards should also be applied to larger existing buildings (i.e. those of more than 1000 m^2) when the buildings undergo substantial renovation.

C) Certification schemes for new and existing buildings on the basis of the above standards and public display of energy performance certificates and recommended indoor temperatures and other relevant climatic factors in public buildings and buildings frequented by the public (Article 6). The European Commission believes that clear information will influence the rent that owners can set and therefore will be an incentive for them to make investments in the energy efficiency of buildings and houses. As the tenant normally pays the energy bill, currently the incentive for the owner to invest in energy efficiency is low. Making clear and reliable energy performance information available to prospective tenants ought to help make these investments more attractive. The certificates, which should not be more than five years old, should include accompanying advice on how to improve the energy performance of the building. Certification for new buildings is at present mandatory in Denmark and Germany. For existing buildings, only Denmark has a mandatory scheme, but several Member States have voluntary programmes. The European Commission highlights the example of Denmark, where "certification together with the implementation of identified measures, has provided a more than 13% return on investments".

D) Specific inspection and assessment of boilers and heating/cooling installations (Articles 7 and 8). Boilers with an effective output of more than 10 kW (although most boilers of under 10 kW are adequate for smaller dwellings, domestic combination boilers are generally rated at over 20 kW), with accumulation capacity up to boilers for blocks of flats and offices, should be regularly inspected to improve their operating conditions. Such an inspection is compulsory in 10 Member States, whilst the others apply voluntary schemes and information programmes. Provision has also been made for the regular inspection of air conditioning systems with an effective output of more than 12 kW.

2.3 Evaluation and Application Issues

It goes without saying that the proposed Directive has only good and logical intentions, objectives and scope. However, it is not clear from the document how the proposed measures will be applied, and what evaluation and assessment techniques will be the most appropriate.

The document stipulates that new buildings must comply with minimum energy performance standards. However, nowhere in the Directive or its annexes are these minimum standards -whether common, or specific to each Member State,- defined and no statement is made or advice given on how to make this effective. The Directive also refers to energy performance certificates for new and existing buildings but does not specify what these should include or who will be eligible to provide such certificates. Neither are adequate details provided regarding exactly what information should be displayed in public buildings/buildings frequented by the public, what the recommended values for these units should be and whether these will be "measured" by prediction or by monitoring. Moreover, the Directive does not clarify how the inspections and the assessments of boilers and air-conditioning systems should be effected: e.g. by monitoring or by applying other practical measures? The Directive also emphasises a common methodology for evaluation of integrated energy performance standards by changing the National Regulations of the Member States, but it is not clear by what means all of the factors concerned with the calculation of the energy performance (insulation, heating and cooling installations, etc.) should be integrated and by whom the performance will be evaluated – whether by self certification or by registered assessors.

2.4 Assessment Options and Opportunities

Despite the fact that the Directive is unclear with regard to method of assessment, nevertheless it offers an opportunity to, and challenges for, building design professionals. One method by which the design community could rise to this challenge is to begin to address the issue of integrated performance (as set out in the Directive) as a standard in-house activity and one method by which this could be achieved is through the use of integrated performance appraisal. By so doing, these professionals would find themselves in a position whereby whatever method the European Commission eventually adopts, they would be prepared to respond.

There are many possible methods and systems that could be used to undertake such an evaluation but most of these are steady state models and therefore cannot truly predict overall annual performance. However, the adoption of a dynamic simulation approach is one method that could possibly address very well the requirements of the Directive. The next phase of this project will therefore attempt to examine the option of integrated performance assessment with regard to assessment of the Energy Performance Directive by the use of dynamic building simulation.

3 Integrated simulation as a method to assess the Energy Performance Directive

As suggested at the end of the previous chapter, a dependable energy performance assessment would require the use of a dynamic technique, involving complex algorithms that take into account specific attributes of the building and its context. The lengthy calculations required to estimate year-round energy behaviour together with developments in computing power over the last three decades have hastened the development of building energy design tools, both manual and computer based. However, one tool that can estimate the integrated energy performance of buildings and which –as will be demonstrated in this project- can make it possible to achieve the objectives of the Directive, is integrated simulation. Integrated simulation allows owners, tenants and designers of buildings to understand the interrelationships between building design and performance parameters, to identify potential problem areas and in this way to implement and test appropriate design and retrofit building modifications. The aim of integrated simulation is to preserve the integrity of the entire building/plant system by simultaneously processing all of the energy transport paths at a level of detail commensurate with the objectives of the problem in hand and the uncertainties inherent in the describing data[9]. To this end, a building should be regarded as being systemic (many parts make the whole), dynamic (the parts evolve at different rates), non-linear (the parameters depend on the thermodynamic state) and, above all, complex (there are myriad intra- and inter-part interactions). To achieve high modelling integrity, a simulation program aims to preserve these intrinsic characteristics.

The complexity and sometimes, the computational power requirements and the associated cost, have, in the past, been the main barriers, to adopting energy simulation tools for professionals dealing with energy matters in buildings. However, in the last few years, computational power has advanced significantly and thus, simulation tools have been developed, which now allows professionals access to simulation without demanding high computational power and generally at a lower cost than previously. And with regard to the barrier of the complexity in using simulation, there are now emerging new and cheaper ways of training on these tools (e.g. online tutorials, distance learning courses, specialist support agencies[10]). All of these are making it easier for professionals to use simulation and by thus, to address the issues of the Directive. So, now even if the new Directive does not specify implementation methods, professionals dealing with energy matters in buildings may now have an opportunity to address all of the associated issues by using energy simulation tools. In addition, the wider use of simulation will be beneficial in terms of producing results against which the measures outlined in the energy performance Directive can be evaluated and implemented, thus proving the simulation route to compliance.

4 Simulation: The options

4.1 *Selecting a tool*

Nowadays, construction design professionals have access to many respected energy simulation tools, concerned with the energy performance of buildings. The best-known examples are: EnergyPlus, DOE-2, BLAST, TRNSYS, SPARK, ESP-r, TAS, etc. Of these programs, the author had access to ESP-r and therefore this was the model selected for this thesis as a test-bed for the hypothesis that dynamic simulation could be used by design professionals to meet the proposed requirements of the new Directive.

The ESP-r system has evolved to its present form over more than two decades. From 1974 to 1977 the University of Strathclyde[11] developed the initial prototype and since then funding from various sources including the UK's Engineering and Physical Science Research council and the R&D Framework Programmes of the European Commission the model has been continuously developed at the Energy Systems Research Unit (ESRU) of the University of Strathclyde.

ESP-r is able to model the energy and fluid flows within combined building and plant systems. In total, a number of interrelating program modules that address project management; simulation; database management; results recovery and display and report writing. In terms of geometry, construction and usage profiles, buildings are divided to one or more zones. These zones are then inter-locked to form a building, in whole or in part, and moreover leakage distribution is defined to enable air flow simulation if required. A plant network may be defined by connecting individual components. Finally, the multi-zone building and the multi-component plant are connected and subjected to simulation processing against user-defined control. The entire data preparation is achieved interactively, and with the aid of pre-existing databases that contain standard event profiles, constructions and plant components. Additional modules exist to permit an increase in simulation rigour if the related data is available. A central Project Manager allows importing/ exporting of building geometry from/ to CAD packages and other specialised simulation environments such as Radiance for lighting simulation.

ESP-r is equally applicable to existing buildings and new designs, with or without advanced technological features. By using ESP-r and by inserting the appropriate inputs, professionals can estimate[13]:

- The peak building or plant loads and the rank-ordered causal energy flows.
- The effect of some design change, such as increasing wall insulation, altering the window size and shape, changing the glazing type or distribution, re-zoning the building, introducing daylight control devices, re-configuring the plant or changing the heating/cooling control regime.
- The optimum plant start time or the most effective algorithm for weather anticipation.
- The variation of comfort levels throughout the building.
- The benefits that should be expected from the different possible lighting control strategies.
- The relative merits of different heating and cooling systems and their associated controls.
- The effect of temperature stratification, in terms of zone sensor and terminal unit location, on energy consumption and on comfort control.
- The contribution that building infiltration and zone-coupled air flow make to total boiler or chiller load and ways of minimising this.
- The effect of suggested design alterations to the air flow and to fresh air distribution (i.e. indoor air quality) within the building.
- The effect of special glazings (such as holographic, thermotropic, low-e or electrochromic glazing) on summer overheating.
- The benefits of architectural building features such as atria, courtyards, sunspaces, etc.
- The contribution, in terms of energy saving and thermal comfort, of a range of passive solar (heating or cooling) features.
- The optimum arrangement of constructional elements to encourage good load levelling and hence efficient plant operation.
- The energy consequences of non-compliance with prescriptive energy regulations or, conversely, how a design should be modified to come within some deemed-to-satisfy performance target.

- The appropriate heat recovery system that performs best under a range of typical operating conditions and so on.

This allows the user to understand better the interrelationships between design and performance parameters, to then identify potential problem areas, and so to implement and test appropriate building, plant and/ or control modifications. The resultant design should as a result be more energy conscious with better comfort levels attained throughout than would otherwise have been the case.

4.2 Analysis of simulation tool ability to address the requirements of the Directive

As set out in the new Directive, the European Commission aims to improve the energy performance of new and existing buildings and to provide a clear legislative framework, which will create the opportunity to save energy and enhance opportunities for cooperation between Member States. Thus, (and because buildings, as already mentioned before, are responsible for a significant proportion of total energy consumption), basic goals such as the reduction of the greenhouse gases emissions in the atmosphere and the avoidance of the perpetuation of an energy dependant Europe, could be achieved. Akin to this is the innovative proposal that for the first time, according to the Directive (ANNEX), a common methodology of calculation of energy performances of buildings should be established and that the targets should be achieved by integrating the aspects listed below. A s a first step, although the final case study considers only ESP-r, with a view to establishing how easy it would be to adopt a modelling approach generally, a brief assessment of how well, or otherwise, some of the best simulation tools handle each of respected these key aspects is outlined in each section.

- **Thermal insulation:** This aspect includes insulation for both building shell and building/plant installations. The most important issue to be considered with regard to simulation and that which affects the calculation of energy performances of buildings, is the overall fabric heat loss. This value is determined by the thermal properties of the materials, the convection coefficients and the arrangement of the different insulation layers. Moisture transparency, absorption of solar radiation and diffusion resistance could also be considered here and these also affect the calculation of the energy performance.

ESP-r deals very well with the calculations associated with the thermal insulation of the building shell, however it is not really an appropriate tool for building/plant installations insulation calculations as it does not model plant at this level of detail. The VE[14] simulation tool and more specifically the INDUS Pro and the PISCES Procan, which are parts of VE, can make calclulations for the insulation and the sizing of ducts and pipes installations. IES, the developers of VE have recently undertaken a full implementation of the UK 2002 Building Regulations relating to the conservation of fuel and power. In addition, the TAS[15] simulation tool also copes well with plant installations because it combines building and plant simulation and automatically determines component sizes. EDSL, the developers of TAS have also recently designed a new UK 2002 Building Regulations relating to the conservation of fuel and power compliance checker. Thus all of these tools could be used to deal with this aspect of the Directive, although ESP-r may need to deal with plant modelling differently of by modification.

- **Heating installation and hot water supply:** The efficiency of the HVAC installations and especially of the boiler is also an important factor that should be considered during the calculation of the energy performance of a building. More specifically, the efficiency should be considered for both full and part load. Additionally, the boiler sizing compared with the heating requirements of the building has important role to play in the calculation of the energy performance of a building. Different types of heating and hot water supply installation (i.e. central heating, district heating, etc.) with different fuels (gas, oil, etc.) and equipment could also be examined in order to increase the efficiency and control the emissions. In this way, improvements in energy performance can be examined and the impact of improved efficiency on CO_2 emissions estimated.

Although, ESP-r produces results concerned with the heating requirements of the building and the heating loads, sizing of the heating installation and boilers requires some manipulation. Some simulation tools which are designed to do this automatically are: VE (APACHE-HVAC); TAS; EnergyPlus[16]; TRNSYS[17].

- **Air-conditioning installation:** Similarly to the heating installation, the efficiency at full and part load of any air-conditioning systems and the sizing of this compared with the cooling requirements affect the energy performance calculation. Different types of air-conditioning installation with different refrigerants (i.e. R12, R22, etc.) and equipment should be examined in order to increase the efficiency, to limit the environmental impacts and as a result to estimate ways to improve the energy performance of the buildings.

  For air-conditioning, ESP-r has similar cabilities as it has for heating installation design. In other words, plant sizing is not automatic. The same simulation tools as previously (VE (APACHE-HVAC); TAS; EnergyPlus; TRNSYS) have in-built features for the sizing of air-conditioning installations.

- **Ventilation system:** The efficiency and the sizing of ventilation systems compared with fresh air requirements also affect the calculation of the energy performance of the building. Moreover, the various ventilation systems (i.e. mechanical, natural, etc.) should be examined at every stage of the design process for differences in the energy performance of a building as the design evolves.

  ESP-r is a very good tool for ventilation system design and analysis. Alternative tools with similar capabilities are: EnergyPlus and TAS.

- **Lighting installation:** The efficiency (or the energy consumption) of lamps and luminaries should be considered in the calculation of the energy performance of buildings and the option of using high efficiency lamps and luminaries should be examined. In addition, the introduction of daylight, the effects of room surface reflectance properties, visual comfort, lighting control strategies and alternative daylight capture and shading strategies will affect the energy performance.

Many simulation tools deal specifically with this aspect. Radiance[18], EnergyPlus and TAS for example. VE and ESP-r have their own Radiance interfaces.

- **Position and orientation of buildings:** The impacts of wind speed and direction as it impacts on the wall surfaces of a building are important for the calculation of the energy performance (because for example, the convection coefficient and the heat losses or gains are affected by the wind's speed and direction). By constructing the buildings in an appropriate position or orientation, the wind speed and the wind direction can be controlled in a way that would improve the energy performance of the building. The same should happen by checking, basically for active solar gains, the solar radiation to the surfaces of a building and the ground reflectance, mainly for the reflectance of the solar radiation to the building surfaces.

  ESP-r ideally suited for the study of this aspect but TAS, VE, EnergyPlus and TRNSYS simulation tools also give good results.

- **Solar systems and other heating and electricity systems based on renewable energy sources:** The potential benefit of any additional energy production from these systems should be considered as a positive factor in the calculation of energy performances of buildings and the associated contribution to the reduction of CO_2 emissions. Therefore, if considering such systems, these should be optimally sized to meet appropriate proportions of the building's energy demands. However, as such systems can be expensive to install, resulting in highly paybacks, feasibility studies comparing their costs with those of conventional systems should be carried out in all cases.

  ESP-r is very reliable for this aspect but TRNSYS and Energy Plus (DOE-2) have also very good performance.

- **Electricity produced by CHP and/or district heating systems:** Similarly to the renewable energy sources systems outlined above, any additional production from these systems affects the energy performance calculation. A comparison of this production with the demand and a feasibility study for the cost of these systems are also essential.

ESP-r and TRNSYS simulation tools have very good flexibility to address this aspect.

It should be noted that the Life Cycle Analysis of all of these aspects should be considered during the process of calculation of the energy performances of buildings. The value of the energy performance will change during the life cycle of the equipment that is concerned with the above aspects.

Although it is not explicit in the Directive, there are few additional aspects that the methodology of calculation of energy performances of buildings should consider. These aspects are:

- **Climatic conditions:** The ambient temperature, humidity and wind speed are some of the basic factors that should be considered during the calculation of energy performances of buildings. Comparing for example identical buildings, which are located in places with different climatic conditions, it is evident that the heating and cooling requirements will be different. In other words, if these buildings had the same heating and air-conditioning systems, then the efficiency of these systems would not be the same.

  All of the reliable simulation tools are taking into account the climate conditions that buildings are placed. ESP-r and EnergyPlus are the most respected in this area.

- **Indoor air quality:** The energy performance of the building will be affected by the condition of the air inside the buildings (i.e. for buildings in different climates) and in particular the temperature and humidity.

  ESP-r can deal very well with this aspect by giving comfort assessments for the occupants of the building. Other simulation tools, which address very well this aspect, are VE and EnergyPlus.

- **Occupation density:** Higher occupancy levels result in a requirement for fewer buildings and lower overall CO_2 emissions from the built environment but at the same time can result in higher energy consumption per building due to increased cooling loads, and power requirements. This affects the calculation of energy performances of buildings.

Suggested simulation tools to examine this aspect are the ESP-r, TAS and VE (APACHE).

- **Building envelope air tightness:** The air tightness of the building envelope will affect the conditions of the air inside the building or the energy consumption (e.g. for heating) and it should thus be considered in the calculation of the energy performance.

  ESP-r is a very good simulation tool to deal with this aspect. Additionally, VE (APACHE), EnergyPlus, TAS and TRNSYS could be used for the same purpose.

It is clear that to address all of these issues is a highly complex issue that could present barriers to the implementation of the Directive. Despite the fact that not all simulation tools can yet deal with all of the above issues, it still remains that only simulation could attempt to balance out all of the interactions and the interrelationships between them.

5 How integrated simulation could be used to address the Directive: A case study

5.1 General issues for the case study

To investigate how these aspects can be integrated by using simulation, a case study was selected and some of the key aspects: the thermal insulation; the heating installation; the indoor air quality; the climate conditions; the orientation of the building; the air tightness and the occupation density were studied in detail with ESP-r.

The building (Figure 2), to be examined as the case study, is a two-floor office block located in the northeast of Scotland. In additionto UK climate, but climate data from Milan in Italy was also used to test performance of the same building in this alternative location. The building is represented as 17 zones - 1 for each lettable space, 1 for toilets, 3 for entry, 2 for stairs, 3 for ceiling voids and 1 for the roof space.

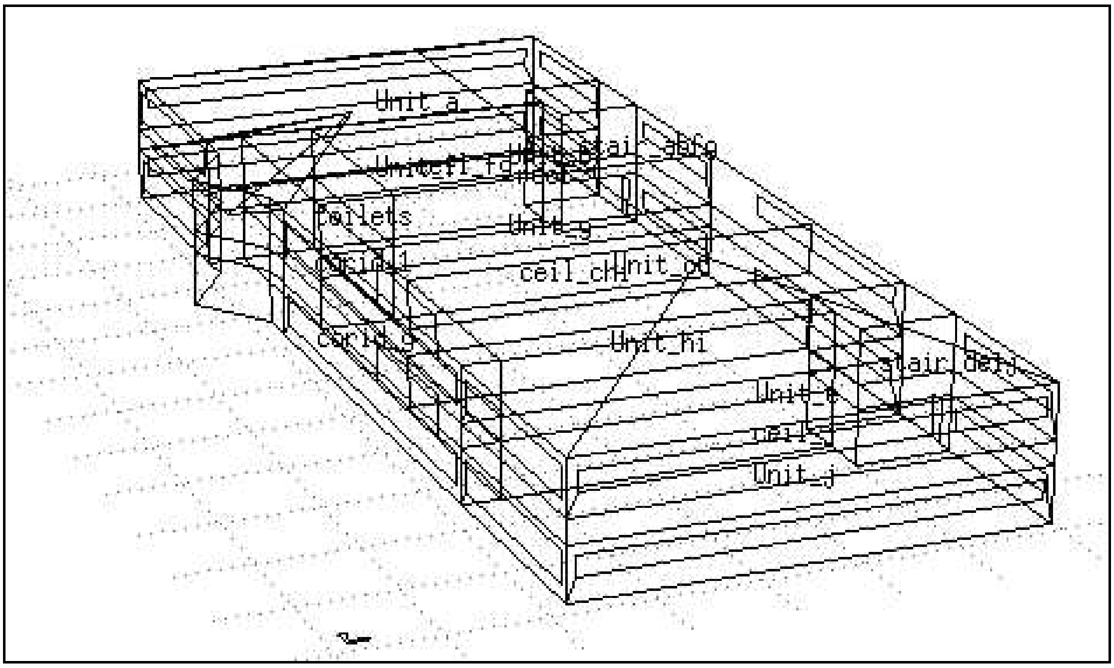


Figure 2

5.2 Thermal insulation

The issue of thermal insulation is defined in the simulation by inserting and specifying inputs. The material properties of the building constructions (walls, windows, etc.) and for every thermal zone, for example, have to be defined. In ESP-r, this is done by creating new or selecting from the pre-defined, existing materials and constructions databases. In order to create a new materials database, the name and the thermo-physical properties of the required materials must be inserted into the simulation program. These thermo-physical properties are: the conductivity, the density, the specific heat, the emissivity, the absorptivity and the diffusion resistance. Although materials manufacturers can often provide these properties, ESP-r's materials library includes the most common materials that are used in buildings. Thus for the most part, users do not have to search out materials properties. The next step is to define the details for the constructions (walls, windows, etc.) of the building. Firstly, the name of the construction must be specified and then whether or not it is a transparent or an opaque construction. Additionally, from the materials database, the materials of the layers for each construction must be selected. The thickness of these layers is also needed for the calculations and it is specified at this point. Finally, there is an option to add, delete or change the order of the layers.

Applying all of these to the case study will make clearer the method of calculation:

For one of the spaces that is used as an office, zone 3 or *unit_f* (Figure 3) of the building, the U values of the constructions are going to be calculated. For the construction *prt_f-t* for example, the construction database file is created (Figure 4) by taking from the materials databases (Figure 5) the materials –or by creating new databases- and by specifying the thickness of every layer of the surface. The overall heat transfer coefficient is automatically calculated by ESP-r (U value = 1.18 W/m^2K) -as will be more obvious later- by changing any of these inputs. By doing this to all of the surfaces, all the U values of the zone are calculated. Moreover ESP-r has the ability to output a list (Figure 6) with the thermo-physical details of all the surfaces and to save them to a file by capturing the text.

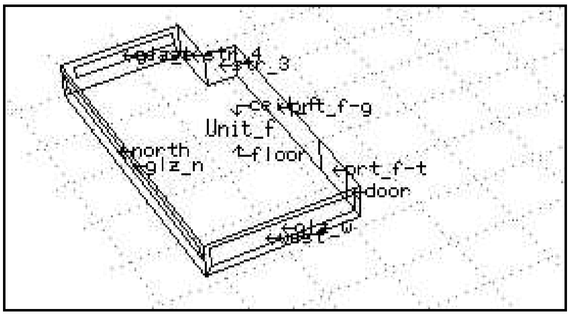
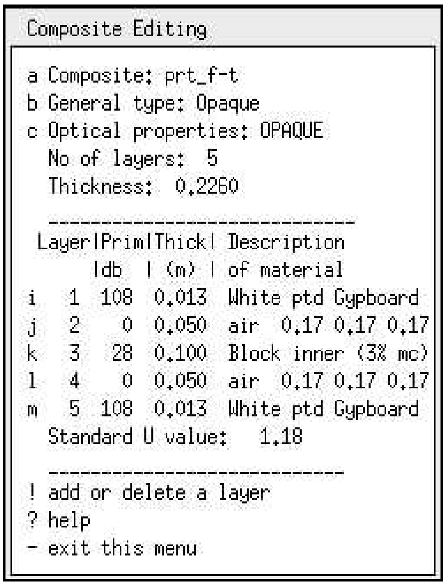
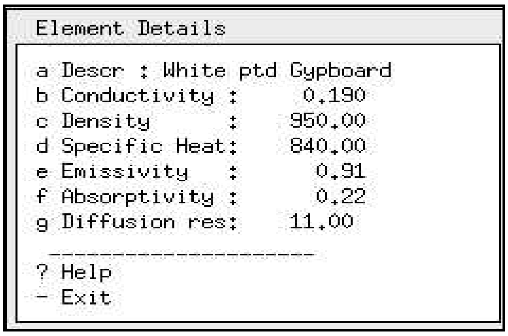


Figure 3



```
Composite Editing
a Composite: prt_f-t
b General type: Opaque
c Optical properties: OPAQUE
  No of layers:  5
  Thickness:  0.2260
  -----------------------------
 Layer|Prim|Thick| Description
      |db  | (m) | of material
i   1  108  0.013  White ptd Gypboard
j   2    0  0.050  air  0.17 0.17 0.17
k   3   28  0.100  Block inner (3% mc)
l   4    0  0.050  air  0.17 0.17 0.17
m   5  108  0.013  White ptd Gypboard
  Standard U value:   1.18
  ----------------------------
! add or delete a layer
? help
- exit this menu
```

Figure 4



```
Element Details
a Descr : White ptd Gypboard
b Conductivity :     0.190
c Density      :    950.00
d Specific Heat:    840.00
e Emissivity   :      0.91
f Absorptivity :      0.22
g Diffusion res:    11.00
 ----------------------
? Help
- Exit
```

Figure 5

Zone construction details for Unit_f (3)

Surface	Layer	Mat db	Thick (m)	Conductivity	Density	Specif heat	IR emis	Solr abs	Description
prt_f-t	1	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	2	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	3	28	0.1000	0.510	1400.0	1000.0			Block inner (3% mc)
	4	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	5	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	Standard U value for construction gyp_blk_ptn is 1.18								
prt_f-g	1	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	2	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	3	28	0.1000	0.510	1400.0	1000.0			Block inner (3% mc)
	4	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	5	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	Standard U value for construction gyp_blk_ptn is 1.18								
str_3	1	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	2	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	3	28	0.1000	0.510	1400.0	1000.0			Block inner (3% mc)
	4	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	5	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	Standard U value for construction gyp_blk_ptn is 1.18								
str_4	1	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	2	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	3	28	0.1000	0.510	1400.0	1000.0			Block inner (3% mc)
	4	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	5	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	Standard U value for construction gyp_blk_ptn is 1.18								
east	1	46	0.0040	210.000	2700.0	880.0	0.82	0.72	Grey cotd aluminium
	2	281	0.0800	0.040	12.0	840.0			Glass Fibre Quilt
	3	47	0.0040	210.000	2700.0	880.0	0.82	0.32	Wt cotd aluminium
	Standard U value for construction insul_mtl_p is 0.46								
north	1	46	0.0040	210.000	2700.0	880.0	0.82	0.72	Grey cotd aluminium
	2	281	0.0800	0.040	12.0	840.0			Glass Fibre Quilt
	3	47	0.0040	210.000	2700.0	880.0	0.82	0.32	Wt cotd aluminium
	Standard U value for construction insul_mtl_p is 0.46								
west	1	46	0.0040	210.000	2700.0	880.0	0.82	0.72	Grey cotd aluminium
	2	281	0.0800	0.040	12.0	840.0			Glass Fibre Quilt
	3	47	0.0040	210.000	2700.0	880.0	0.82	0.32	Wt cotd aluminium
	Standard U value for construction insul_mtl_p is 0.46								
ceil_f	1	104	0.0130	0.420	1200.0	837.0	0.91	0.50	Gypsum plaster
	Standard U value for construction susp_ceil is 4.79								
floor	1	263	0.2500	1.280	1460.0	879.0	0.90	0.85	Common_earth
	2	262	0.1500	0.520	2050.0	184.0			Gravel based
	3	32	0.1500	1.400	2100.0	653.0			Heavy mix concrete
	4	0	0.0500	0.000	0.0	0.0			air gap (R= 0.170)
	5	67	0.0190	0.150	800.0	2093.0			Chipboard
	6	221	0.0060	0.060	186.0	1360.0	0.90	0.60	Wilton
	Standard U value for construction grnd_floor is 0.86								
door	1	69	0.0250	0.190	700.0	2390.0	0.90	0.65	Oak (radial)
	Standard U value for construction door is 3.23								
glz_e	1	242	0.0060	0.760	2710.0	837.0	0.83	0.05	Plate glass
	2	0	0.0120	0.000	0.0	0.0			air gap (R= 0.170)
	3	242	0.0060	0.760	2710.0	837.0	0.83	0.05	Plate glass
	Standard U value for construction dbl_glz is 2.75								
glz_n	1	242	0.0060	0.760	2710.0	837.0	0.83	0.05	Plate glass
	2	0	0.0120	0.000	0.0	0.0			air gap (R= 0.170)
	3	242	0.0060	0.760	2710.0	837.0	0.83	0.05	Plate glass
	Standard U value for construction dbl_glz is 2.75								
glz_w	1	242	0.0060	0.760	2710.0	837.0	0.83	0.05	Plate glass
	2	0	0.0120	0.000	0.0	0.0			air gap (R= 0.170)
	3	242	0.0060	0.760	2710.0	837.0	0.83	0.05	Plate glass
	Standard U value for construction dbl_glz is 2.75								

Figure 6

5.3 Heating Installation

5.3.1 Control

In order to study the heating installation aspect to which the Directive refers, a control file has to be created in ESP-r to provide realistic environmental controls for zones, plant systems and fluid flow networks. Without this, the simulation would be "free floating", in other words without any environmental control. Within ESP-r the hierarchy and data required to set this up is:

1) Overall control file definition
    - Sub-system definitions
        - Zones
        - Plants
        - Flow
        - Global

2) Defined control loops
    - Sensor location
        - Aspects to be sensed
    - Actuator location
    - Number of day types

3) Defined day types
    - Number of control periods
    - Start and finish date of validity
    - Controller type
    - Control law
    - Start time
    - Number of data items associated with control law
    - Data values such as maximum and minimum heating capacity, temperature setpoints for the heating, etc.

Finally, these loops must be linked with the zones. By using control file in the simulation process, typical outputs relating to the heating installation performance can be extracted from the result analysis of the simulation. For example, the sensible heating requirements are estimated for every different zone and for the whole building. Information regarding the energy (in kWh) that has to be delivered to each zone of the building and the number of hours required for heating is produced by the simulation. Also, all of the sensible and latent loads (in kW) for each specific zone and for the whole building are calculated. The simulation results provide adequate information to allow the user to determine the building's net heating load. However, this simulation tool (ESP-r) does not "size" the heating boiler. The output relies on the users, using their own experience with regard to applying boiler efficiency factors for example. And manufacturer's data with regard to full and part load characteristics would be required to assess annual energy requirements. Thus although there is no direct way direct way to address the Directive from ESP-r results, one option would be to compare the frequency histograms for sensible and latent loads that ESP-r produces with the efficiency-power graphs that manufacturers of standardised boilers provide. However, there are many other dynamic energy simulation tools that can address this aspect more readily than ESP-r (TAS, VE, EnergyPlus, etc.).

The way that ESP-r addresses the aspect of heating as set out in the Directive will be clarified through the aforementioned example:

To test ESP-r's appropriateness to assess heating requirements a control file, *winter2.ctl* was created for the case study office building. The description for the zone control sub-system is *science park* and a single control loop was set up. For this control loop, sensors are sensing the temperature of zone with actuators actuating the zone air point. The days were divided in to W*eekdays*, *Saturdays* and *Sundays* (Figure 7) and the control loop was linked with all zones.

For the *weekdays* three control periods were created with validity dates from the 1st January and ending on the 31st December. The design control periods were: heating on from 08.00 - 17.00 with the rest of the day free floating. The maximum heating capacity was set at 75 kW and the heating sensor setpoint was 20^{o}C (Figure 8). All of the values were selected in order to facilitate examination of how ESP-r handles the aspect of the heating of buildings. For example the 75 kW value was selected after trying out a few different values and checking the results analysis of the loads in different zones for the maximum value (which was found to be just less than 75 kW).

For the *Saturdays* and *Sundays*, one single control period was set. This was the same for both day types, and was created with validity dates also from the 1st January until the 31st December. In this case, the heating is arranged to operate all day if the temperature of the zones is below the heating setpoint. However, in this case, the setpoint was set at 10°C (i.e. relatively low, because the building is not in use at the weekends). The maximum heating capacity was set out to be the same as before and for this reason is again 75 kW (Figure 9).

The aspect of air-conditioning was not examined at this point and consequently the cooling setpoint is set high (100°C). A briefly description of all these:

1) Control file: *winter2.ctl*
   - Sub-system definitions
     - Zones: *science park*

2) *One* control loop
   - Sensors: Sensing the *temperature* of zone
   - Actuators: Actuating the zone *air point*
   - Day types: W*eekdays, Saturdays* and *Sundays*

3) *Weekdays*
   - *Three* control periods
   - Validity from *1st January* to *31st December*
   - Heating on fom *08.00* to *17.00* and the rest of the day *free floating*
   - Maximum heating capacity: *75 kW*, temperature setpoints for the heating: *20°C*

4) *Saturdays and Sundays*
   - *One* control period

- Validity from *1st January* to *31st December*
- Heating on *all day*
- Maximum heating capacity: *75 kW*, temperature setpoints for the heating: *10^{o}C*

```
Controls
a control focus >> zones
b description: science park
c description: winter heating
  loops      :  1
d link loops to zones
 ------------------------------------------
 cntl| sensor |actuator|day |valid |period
 loop|location|location|type|during|in day
e   1  0  0  0  0  0  0 wkd    1 365    3
f                        Sat    1 365    1
g                        Sun    1 365    1
  -----------------------------------------
+ add/delete/copy control loop or day type
! list or check current control data
> update control data
? help
- exit this menu
```

Figure 7

```
Control periods
 function  1 day type  1
 number of periods:  3
 ----------------------------------------
 per|start|sensed   |actuated | control law      | data
 no.|time |property|property |                  |
a  1   0.00 db temp   > flux    free floating
b  2   8.00 db temp   > flux    basic control      75000.0 0.0 0.0 0.0 20.0 100.0 0
c  3  17.00 db temp   > flux    free floating
 ----------------------------------------
* add/ delete a period
? help
- exit
```

Figure 8

```
Control periods

 function  1 day type  2
 number of periods:  1
 ----------------------------------------
 per|start|sensed  |actuated | control law     | data
 no.|time |property|property |                 |
a  1  0.00 db temp   > flux   basic control      75000.0 0.0 0.0 0.0 10.0 100.0 0
 ----------------------------------------
* add/ delete a period
? help
- exit
```

Figure 9

5.3.1.1 Simulation Results

The period between 2nd and 18th February was examined and from the simulation result analysis, the sensible and latent energy for heating was determined for each zone and for the whole building. Moreover, the heating system running hours are also calculated for each separate zone. In total, 21917 kWh of net sensible energy should be required for the simulation period for the building (Figure 10). From the results analysis for this period, the maximum, minimum and mean sensible and latent loads were also calculated for every zone and in addition, the maximum total loads for the whole building. It was found that for this period, the maximum load for the building would be 483 kW and the maximum load for any single zone is 71.73 kW for the *roof* zone (Figure 11). This would allow a design team to pinpoint any problem areas with regard to excessive heat losses (or gains), etc. and to take remedial action. Finally, although as previously stated, the efficiency of the boilers at full and part load cannot be determined directly, different efficiency-load graphs from the manufacturers of the boilers can be combined with the frequency histogram (Figure 12) for the loads of the zones that ESP-r produces in order to determine the efficiency of the boilers during the different loads. However, if ESP-r were to be used as a tool to address the Directive, it is recommended that a link or facility to impact the required manual data should be implemented for this point.

For all these results –as Figures 10 & 11 show- the date and time is known.

Period: Thu 2 Feb @00h50 to: Sat 18 Feb @23h50 Year:1967 : sim@ 20m, output@ 20m

Zone total sensible and latent plant used (kWhrs)

id	Zone name	Sensible heating Energy (kWhrs)	Sensible heating No. of Hr rqd	Sensible cooling Energy (kWhrs)	Sensible cooling No. of Hr rqd	Humidification Energy (kWhrs)	Humidification No. of Hr rqd	Dehumidification Energy (kWhrs)	Dehumidification No. of Hr rqd
1	corid_1	354.82	131.7	0.00	0.0	0.00	0.0	0.00	0.0
2	corid_g	834.24	196.3	0.00	0.0	0.00	0.0	0.00	0.0
3	Unit_f	2523.41	227.7	0.00	0.0	0.00	0.0	0.00	0.0
4	Unit_g	800.75	181.0	0.00	0.0	0.00	0.0	0.00	0.0
5	Unit_j	3497.94	223.3	0.00	0.0	0.00	0.0	0.00	0.0
6	Unit_a	3133.58	227.3	0.00	0.0	0.00	0.0	0.00	0.0
7	Unit_b	516.85	111.7	0.00	0.0	0.00	0.0	0.00	0.0
8	Unit_e	3172.99	219.3	0.00	0.0	0.00	0.0	0.00	0.0
9	Unit_hi	1694.62	150.0	0.00	0.0	0.00	0.0	0.00	0.0
10	Unit_cd	868.83	112.0	0.00	0.0	0.00	0.0	0.00	0.0
11	ceil_fg	633.09	118.3	0.00	0.0	0.00	0.0	0.00	0.0
12	ceil_chi	695.88	112.0	0.00	0.0	0.00	0.0	0.00	0.0
13	ceil_j	348.53	122.7	0.00	0.0	0.00	0.0	0.00	0.0
14	stair_abfg	166.27	148.7	0.00	0.0	0.00	0.0	0.00	0.0
15	stair_deij	176.49	142.3	0.00	0.0	0.00	0.0	0.00	0.0
16	toilets	288.46	112.0	0.00	0.0	0.00	0.0	0.00	0.0
17	roof	2209.88	176.3	0.00	0.0	0.00	0.0	0.00	0.0
	All	21916.63		0.00		0.00		0.00	

Figure 10

Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	14.92	15 Feb@08h30	0.00	2 Feb@00h10	0.87	1.88
corid_g	17.24	15 Feb@08h30	0.00	2 Feb@00h10	2.04	3.46
Unit_f	54.12	15 Feb@08h30	0.00	2 Feb@00h10	6.18	10.55
Unit_g	20.97	15 Feb@08h50	0.00	2 Feb@00h10	1.96	3.86
Unit_j	59.33	15 Feb@08h30	0.00	2 Feb@00h10	8.57	13.20
Unit_a	58.72	15 Feb@08h30	0.00	2 Feb@00h10	7.68	11.78
Unit_b	20.07	15 Feb@08h30	0.00	2 Feb@00h10	1.27	3.18
Unit_e	58.57	15 Feb@08h30	0.00	2 Feb@00h10	7.78	12.10
Unit_hi	34.54	15 Feb@08h50	0.00	2 Feb@00h10	4.15	7.23
Unit_cd	29.25	14 Feb@08h09	0.00	2 Feb@00h10	2.13	4.69
ceil_fg	16.37	14 Feb@08h50	0.00	2 Feb@00h10	1.55	2.85
ceil_chi	16.75	13 Feb@08h50	0.00	2 Feb@00h10	1.71	3.04
ceil_j	10.53	14 Feb@08h50	0.00	2 Feb@00h10	0.85	1.65
stair_abfg	4.65	15 Feb@08h30	0.00	2 Feb@00h10	0.41	0.77
stair_deij	4.56	15 Feb@08h30	0.00	2 Feb@00h10	0.43	0.81
toilets	10.96	14 Feb@08h09	0.00	2 Feb@00h10	0.71	1.57
roof	71.73	15 Feb@08h30	0.00	2 Feb@00h10	5.42	9.99
All	482.73	15 Feb@08h30	0.00	2 Feb@00h00		

Figure 11

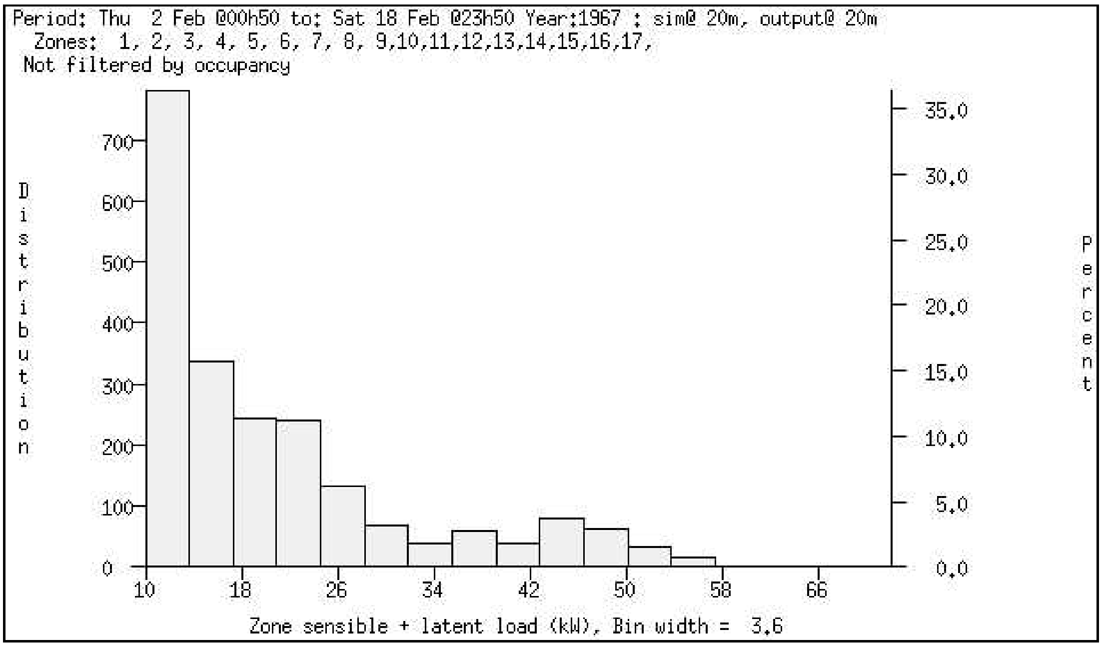

Period: Thu 2 Feb @00h50 to: Sat 18 Feb @23h50 Year:1967 : sim@ 20m, output@ 20m
Zones: 1, 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,13,14,15,16,17,
Not filtered by occupancy
Distribution
Percent
0
100
200
300
400
500
600
700
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
10
18
26
34
42
50
58
66
Zone sensible + latent load (kW), Bin width = 3.6

Figure 12

5.4 *Changing different energy performance aspects, Integration*

By implementing changes to the various inputs of the two previously examined aspects and moreover of the aforementioned aspects (climate conditions, orientation, etc.), it should be possible to clarify how the simulation automatically takes into account any changes and then produces new results which enable us to derive new conclusions for the energy performance of the building.

5.4.1 Changing the thickness of the building materials

For example, in two of the offices, a change to the material thicknesses of some of the constructions of *Unit_f* and *Unit_g* zones will result in changes to the U values of these constructions and to the outputs concerned with the heating requirements. ESP-r produces all of the new results automatically. In order to test this, the surfaces, which were modified, are:

- *prt_f-t*, *prt_f-g*, *east*, *north* and *west* for the *Unit_f* zone
- *prt_g-h*, *east*, *prt_f-g* and *prt_t* for *Unit_g* zone

The changes to the thickness of the materials and the resultant new U values are shown in Figures 13a and 13b.

Zone construction details for Unit_f (3)

Surface	Layer	Mat db	Thick (m)	Conduc-tivity	Density	Specif heat	IR emis	Solr abs	Description
prt_f-t	1	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	2	0	0.0750	0.000	0.0	0.0			air gap (R= 0.170)
	3	28	0.4000	0.510	1400.0	1000.0			Block inner (3% mc)
	4	0	0.0750	0.000	0.0	0.0			air gap (R= 0.170)
	5	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	Standard U value for construction gyp_blk_ptn is 0.69								
prt_f-g	1	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	2	0	0.0750	0.000	0.0	0.0			air gap (R= 0.170)
	3	28	0.4000	0.510	1400.0	1000.0			Block inner (3% mc)
	4	0	0.0750	0.000	0.0	0.0			air gap (R= 0.170)
	5	108	0.0130	0.190	950.0	840.0	0.91	0.22	White ptd Gypboard
	Standard U value for construction gyp_blk_ptn is 0.69								

Figure 13a

```
east             1   46 0.0040  210.000  2700.0   880.0 0.82 0.72 Grey cotd aluminium
                 2  281 0.2800    0.040    12.0   840.0           Glass Fibre Quilt
                 3   47 0.0040  210.000  2700.0   880.0 0.82 0.32 Wt cotd aluminium
             Standard U value for construction insul_mtl_p is  0.14
north            1   46 0.0040  210.000  2700.0   880.0 0.82 0.72 Grey cotd aluminium
                 2  281 0.2800    0.040    12.0   840.0           Glass Fibre Quilt
                 3   47 0.0040  210.000  2700.0   880.0 0.82 0.32 Wt cotd aluminium
             Standard U value for construction insul_mtl_p is  0.14
west             1   46 0.0040  210.000  2700.0   880.0 0.82 0.72 Grey cotd aluminium
                 2  281 0.2800    0.040    12.0   840.0           Glass Fibre Quilt
                 3   47 0.0040  210.000  2700.0   880.0 0.82 0.32 Wt cotd aluminium
             Standard U value for construction insul_mtl_p is  0.14
```

```
 Zone construction details for Unit_g ( 4)

Surface      |Layer|Mat|Thick  |Conduc-|Density |Specif|IR  |Solr| Description
             |     |db | (m)   |tivity |        |heat  |emis|abs |
prt_g-h          1  108 0.0130    0.190   950.0   840.0 0.91 0.22 White ptd Gypboard
                 2    0 0.0750    0.000     0.0     0.0           air gap (R= 0.170)
                 3   28 0.4000    0.510  1400.0  1000.0           Block inner (3% mc)
                 4    0 0.0750    0.000     0.0     0.0           air gap (R= 0.170)
                 5  108 0.0130    0.190   950.0   840.0 0.91 0.22 White ptd Gypboard
             Standard U value for construction gyp_blk_ptn is  0.69
east             1   46 0.0040  210.000  2700.0   880.0 0.82 0.72 Grey cotd aluminium
                 2  281 0.2800    0.040    12.0   840.0           Glass Fibre Quilt
                 3   47 0.0040  210.000  2700.0   880.0 0.82 0.32 Wt cotd aluminium
             Standard U value for construction insul_mtl_p is  0.14

prt_f-g          1  108 0.0130    0.190   950.0   840.0 0.91 0.22 White ptd Gypboard
                 2    0 0.0750    0.000     0.0     0.0           air gap (R= 0.170)
                 3   28 0.4000    0.510  1400.0  1000.0           Block inner (3% mc)
                 4    0 0.0750    0.000     0.0     0.0           air gap (R= 0.170)
                 5  108 0.0130    0.190   950.0   840.0 0.91 0.22 White ptd Gypboard
             Standard U value for construction gyp_blk_ptn is  0.69
prt_t            1  108 0.0130    0.190   950.0   840.0 0.91 0.22 White ptd Gypboard
                 2    0 0.0750    0.000     0.0     0.0           air gap (R= 0.170)
                 3   28 0.4000    0.510  1400.0  1000.0           Block inner (3% mc)
                 4    0 0.0750    0.000     0.0     0.0           air gap (R= 0.170)
                 5  108 0.0130    0.190   950.0   840.0 0.91 0.22 White ptd Gypboard
             Standard U value for construction gyp_blk_ptn is  0.69
```

Figure 13b

As shown in Figures 14 and 15, re-running the simulation with these changes only was found to affect the heating results and more precisely, the sensible and latent energy which has to be used for heating, the number of hours for which the heating is required and the overall heating loads. The ESP-r simulations automatically produce these new results for each different zone. The total net sensible energy now predicted for heating is reduced as a result of the changes from *21917 kWh* to *21854 kWh* and the total loads from

483 kW to *482 kW*. Although these results are not significantly different from the previous set, if similar changes were applied to all of the constructions of the zone, the results could be significantly different and similarly, every zone would have different heating requirements. Without using simulation, the calculation of these requirements would be a very time-consuming process; however, simulation is able to provide results quickly and more accurately than the traditional steady state methods.

id	Zone name	Sensible heating Energy (kWhrs)	No. of Hr rqd
1	corid_1	354.60	131.7
2	corid_g	832.94	196.3
3	Unit_f	2493.24	225.7
4	Unit_g	782.36	175.7
5	Unit_j	3497.88	223.3
6	Unit_a	3131.07	227.3
7	Unit_b	515.23	111.7
8	Unit_e	3172.82	219.3
9	Unit_hi	1694.96	150.3
10	Unit_cd	868.39	112.0
11	ceil_fg	626.70	114.3
12	ceil_chi	695.55	112.0
13	ceil_j	348.46	122.7
14	stair_abfg	165.28	148.0
15	stair_deij	176.46	142.3
16	toilets	287.83	112.0
17	roof	2210.44	176.0
	All	21854.20	

Figure 14

Period: Thu 2 Feb @00h50 to: Sat 18 Feb @23h50 Year:1967 : sim@ 20m, output@ 20m
Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	14.90	15 Feb@08h30	0.00	2 Feb@00h10	0.87	1.88
corid_g	17.15	15 Feb@08h30	0.00	2 Feb@00h10	2.04	3.45
Unit_f	53.94	15 Feb@08h30	0.00	2 Feb@00h10	6.11	10.51
Unit_g	20.55	15 Feb@08h50	0.00	2 Feb@00h10	1.92	3.83
Unit_j	59.32	15 Feb@08h30	0.00	2 Feb@00h10	8.57	13.20
Unit_a	58.71	15 Feb@08h30	0.00	2 Feb@00h10	7.67	11.78
Unit_b	20.06	15 Feb@08h30	0.00	2 Feb@00h10	1.26	3.17
Unit_e	58.56	15 Feb@08h30	0.00	2 Feb@00h10	7.78	12.10
Unit_hi	34.53	15 Feb@08h50	0.00	2 Feb@00h10	4.15	7.23
Unit_cd	29.24	14 Feb@08h09	0.00	2 Feb@00h10	2.13	4.68
ceil_fg	16.12	14 Feb@08h50	0.00	2 Feb@00h10	1.54	2.82
ceil_chi	16.75	13 Feb@08h50	0.00	2 Feb@00h10	1.70	3.04
ceil_j	10.52	14 Feb@08h50	0.00	2 Feb@00h10	0.85	1.65
stair_abfg	4.63	15 Feb@08h30	0.00	2 Feb@00h10	0.41	0.77
stair_deij	4.56	15 Feb@08h30	0.00	2 Feb@00h10	0.43	0.81
toilets	10.92	14 Feb@08h09	0.00	2 Feb@00h10	0.71	1.57
roof	71.71	15 Feb@08h30	0.00	2 Feb@00h10	5.42	10.00
All	481.96	15 Feb@08h30	0.00	2 Feb@00h00		

Figure 15

Similar results would be produced by applying changes to the materials or the construction databases which are used for the building, i.e. rather than changes to the material thickness, as was applied in the case study, changes to the materials which are used, or to their thermo-physical properties and even to the make up of the layers of the different constructions. In other words by trying out different materials and constructions, the energy performance of the building could be altered and ESP-r would again automatically interrelate and integrate these changes with the other energy performance aspects of the building (e.g. heating).

5.4.2 Changing the heating control strategy

Similarly, different heating control strategies could be set in ESP-r, which would alter the heating requirements and thus the size of the required heating installation. This approach is a fully integrated one and hence, these strategies should always take into account the use of the different spaces and the comfort that the users of these spaces feel in order that an integrated solution is obtained. Until now, in the case study, it was assumed that all the zones of the building have the same function and the same heating control was applied to all of them. However, this is not realistic. Some spaces of this building are defined as offices that would be occupied on Weekdays from 09.00 in the morning to 17.00 in the evening, but others, like *roof* zone have no use. In the weekends none of the spaces will be occupied. By taking these facts into account, a new heating control strategy is now proposed and this control strategy (period and heating setpoints) is shown in Table 1:

Zone	Weekdays	Saturdays & Sundays
corid_1	*8.00 – 17.00:* 15 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
corid_g	*8.00 – 17.00:* 15 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_f	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_g	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_j	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_a	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_b	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_e	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_hi	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
Unit_cd	*8.00 – 17.00:* 20 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
ceil_fg	*free floating*	*free floating*
ceil_chi	*free floating*	*free floating*
ceil_j	*free floating*	*free floating*
stair_abfg	10 ^{o}C	10 ^{o}C
stair_deij	10 ^{o}C	10 ^{o}C
toilets	*8.00 – 17.00:* 15 ^{o}C *17.00 – 8.00: free floating*	10 ^{o}C
roof	*free floating*	*free floating*

Table 1

The new control file, *winter4.ctl*, has 3 heating control periods. The heating setpoints were set as the shown in Table 1 with a maximum heating capacity of 65 kW. The control file is presented in detail in Figure 16.

```
Overall description: science park
Zones control: winter heating : 3 functions.

The sensor for function  1 senses the temperature of the current zone.
The actuator for function  1 is air point of the current zone
The function day types are Weekdays, Saturdays & Sundays

Weekday control is valid Sun  1 Jan to Sun 31 Dec, 1967 with  3 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      free floating
  2  8.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 20.0 100.0 0.0
  3 17.00 db temp   > flux      free floating

Saturday control is valid Sun  1 Jan to Sun 31 Dec, 1967 with  1 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 10.0 100.0 0.0

Sunday control is valid Sun  1 Jan to Sun 31 Dec, 1967 with  1 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 10.0 100.0 0.0

The sensor for function  2 senses the temperature of the current zone.
The actuator for function  2 is air point of the current zone
There have been  1 day types defined.

Day type  1 is valid Sun  1 Jan to Sun 31 Dec, 1967 with  1 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 10.0 100.0 0.0

The sensor for function  3 senses the temperature of the current zone.
The actuator for function  3 is air point of the current zone
The function day types are Weekdays, Saturdays & Sundays

Weekday control is valid Sun  1 Jan to Sun 31 Dec, 1967 with  3 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      free floating
  2  8.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 15.0 100.0 0.0
  3 17.00 db temp   > flux      free floating

Saturday control is valid Sun  1 Jan to Sun 31 Dec, 1967 with  1 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 10.0 100.0 0.0

Sunday control is valid Sun  1 Jan to Sun 31 Dec, 1967 with  1 periods.
Per|Start|Sensing  |Actuating  | Control law       | Data
  1  0.00 db temp   > flux      basic control       65000.0 0.0 0.0 0.0 10.0 100.0 0.0
```

Figure 16

By applying this new control file in the simulation, ESP-r re-calculates for each zone separately, the new sensible energy requirements for heating, the number of hours for which the heating is required and the new overall net loads. From the results, it is apparent that the new control strategy has altered the requirements of the building, and some zones (i.e. *roof*) are now without control. The total sensible energy required for heating, the number of running hours for heating and the loads are all reduced as a result of applying the new control strategy (Figures 17 & 18).

Zone id	Zone name	Sensible heating Energy (kWhrs)	Sensible heating No. of Hr rqd
1	corid_1	93.40	77.3
2	corid_g	308.57	162.0
3	Unit_f	2726.07	231.7
4	Unit_g	928.15	197.7
5	Unit_j	3677.86	223.3
6	Unit_a	3503.85	230.0
7	Unit_b	726.67	142.3
8	Unit_e	3506.75	224.0
9	Unit_hi	2043.98	170.7
10	Unit_cd	1322.80	127.0
11	ceil_fg	0.00	0.0
12	ceil_chi	0.00	0.0
13	ceil_j	0.00	0.0
14	stair_abfg	40.32	117.7
15	stair_deij	32.00	93.7
16	toilets	88.04	73.0
17	roof	0.00	0.0
	All	18998.48	

Figure 17

Period: Thu 2 Feb @00h50 to: Sat 18 Feb @23h50 Year:1967 : sim@ 20m, output@ 20m
Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	8.52	15 Feb@08h09	0.00	2 Feb@00h10	0.23	0.85
corid_g	10.39	15 Feb@08h09	0.00	2 Feb@00h10	0.76	1.49
Unit_f	53.03	13 Feb@13h09	0.00	2 Feb@00h10	6.68	11.02
Unit_g	21.28	15 Feb@08h50	0.00	2 Feb@00h10	2.27	4.09
Unit_j	59.32	13 Feb@13h09	0.00	2 Feb@00h10	9.01	13.83
Unit_a	58.20	15 Feb@08h30	0.00	2 Feb@00h10	8.59	12.74
Unit_b	20.81	15 Feb@08h50	0.00	2 Feb@00h10	1.78	3.69
Unit_e	58.05	15 Feb@08h30	0.00	2 Feb@00h10	8.59	13.04
Unit_hi	34.34	15 Feb@08h30	0.00	2 Feb@00h10	5.01	8.27
Unit_cd	31.50	14 Feb@08h30	0.00	2 Feb@00h10	3.24	6.15
ceil_fg	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_chi	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_j	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
stair_abfg	1.11	15 Feb@07h50	0.00	2 Feb@00h10	0.10	0.22
stair_deij	1.01	14 Feb@06h50	0.00	2 Feb@00h10	0.08	0.19
toilets	7.22	14 Feb@08h09	0.00	2 Feb@00h10	0.22	0.83
roof	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
All	359.90	15 Feb@08h30	0.00	2 Feb@00h00		

Figure 18

As mentioned at the beginning of this chapter, the indoor air quality in buildings should be one of the aspects that the calculation of the energy performance of buildings should include. In practice, the comfort of the people who are occupying the places of a building is very important and should also be a part of this thesis.

Simulation tools such as, ESP-r can also produce a *comfort analysis*. This analysis provides a listing of comfort conditions at each time-step of a specific day of the simulation period.

To produce this, some inputs have to be specified within the model prior to simulation. Firstly, for example, for all of the zones and the day and month for which this analysis is required. Moreover, other factors such as the clothing level of the users who are in the zone that is to be studied is also an important factor, as this affects the comfort analysis results and thus, also has to be specified. In ESP-r, this is defined by “clo units” which represent the clothing thermal resistance level in terms of a value between 0 and 3. In addition, one other factor that has to be taken into account during the comfort analysis is the activity level of the users of the building. This is either specified in “MET units” or in “W/m^2 of body surface” and using values from 0.859 to 6.013 and from 50 to 350 respectively. The air velocity (in m/s from 0 to 5) in the zones to be analysed is also required at this stage for ESP-r. Finally, information regarding the occupancy of the zones is the input price to the assessment of the comfort analysis. This information is usually included in the operation file, which includes the information for the casual gains and more specifically for the occupants, lighting and equipment of the specific zone. The occupancy of these zones can also be arranged to be time-based.

By inserting all of this information, a comfort analysis can be undertaken for any zone and any period within a simulation. The simulation users can then test the sensitivity to clothing levels, metabolic rates and other comfort influences.

To clarify this process, an assessment of comfort was undertaken for the case study. A space which is used as office, *Unit_f* zone, was selected as an example and the 2nd of February as an arbitary date for which this analysis will be made. For the clothing level, a typical value for indoor clothing was decided as 1.5 clo units. As the spaces will be used as offices, persons are presumed to be engaged in sedentary work with an activity level set to 58.2 W/m^2 of body surface (or 1 MET). The velocity of the air was been set to 0.1 m/s and the occupancy was arranged as time-based and more precisely it was assumed that the building is occupied only during working indicates hours. Figure 19 shows all of these settings, Figure 20 the casual gains that were set in the operations file and Figures 21a and 21b the results of the comfort analysis for one day for this zone.

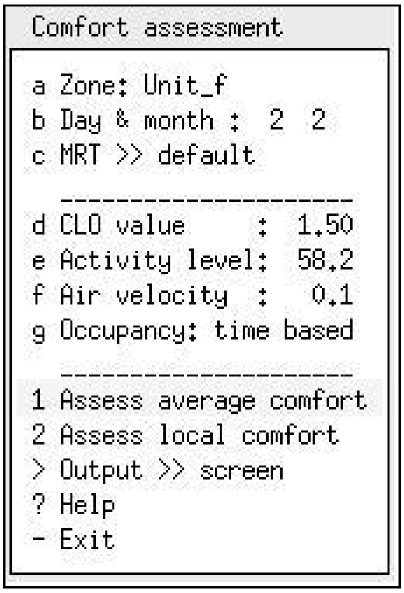


Figure 19

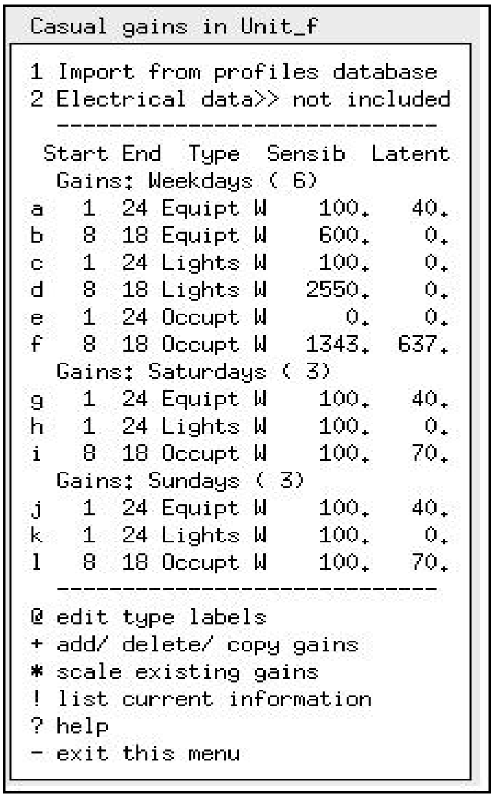


Figure 20

Note: PMV is Fanger predicted mean vote. PMV* is predicted mean vote based on ET rather then TO.

Comfort assessment for Unit_f on Day 2 of month 2

Activity level 58.20, Clothing level 1.50, Air speed 0.10
Default mean radiant temperature

Time (hrs)	t-air (deg.C)	t-mrt (deg.C)	rel.h (%)	SET (deg.C)	PMV* (-)	PMV (-)	PPD (%)	Comfort assessment based on PMV
0.3	10.8	11.6	80.	18.5	-1.05	-1.88	71.	unoccupied
0.7	10.8	11.6	80.	18.5	-1.06	-1.89	71.	unoccupied
1.0	10.7	11.5	81.	18.5	-1.07	-1.89	72.	unoccupied
1.3	10.7	11.5	82.	18.4	-1.07	-1.90	72.	unoccupied
1.7	10.7	11.5	82.	18.4	-1.07	-1.89	72.	unoccupied
2.0	10.7	11.4	83.	18.4	-1.07	-1.89	72.	unoccupied
2.3	10.7	11.4	84.	18.4	-1.07	-1.89	72.	unoccupied
2.7	10.8	11.4	85.	18.4	-1.07	-1.89	71.	unoccupied
3.0	10.8	11.4	85.	18.5	-1.06	-1.88	71.	unoccupied
3.3	10.9	11.4	86.	18.5	-1.05	-1.87	70.	unoccupied
3.7	10.9	11.4	86.	18.5	-1.05	-1.86	70.	unoccupied
4.0	10.9	11.4	85.	18.5	-1.05	-1.87	70.	unoccupied
4.3	10.9	11.4	85.	18.5	-1.05	-1.87	71.	unoccupied
4.7	10.9	11.4	84.	18.5	-1.06	-1.87	71.	unoccupied
5.0	10.9	11.4	84.	18.5	-1.06	-1.88	71.	unoccupied
5.3	10.9	11.4	84.	18.5	-1.06	-1.88	71.	unoccupied
5.7	10.8	11.3	84.	18.4	-1.07	-1.89	71.	unoccupied
6.0	10.7	11.3	84.	18.4	-1.08	-1.90	72.	unoccupied
6.3	10.7	11.3	85.	18.3	-1.09	-1.91	73.	unoccupied
6.7	10.6	11.2	85.	18.3	-1.10	-1.92	73.	unoccupied
7.0	10.6	11.2	84.	18.3	-1.10	-1.93	74.	unoccupied
7.3	10.6	11.2	84.	18.3	-1.11	-1.93	74.	unoccupied
7.7	10.6	11.2	84.	18.3	-1.10	-1.93	73.	unoccupied
8.0	10.7	11.2	85.	18.3	-1.09	-1.92	73.	cool, unpleasant
8.3	15.4	11.5	65.	20.0	-0.67	-1.39	45.	cool, unpleasant
8.7	20.0	12.3	50.	22.0	-0.22	-0.84	20.	cool, unpleasant
9.0	20.0	13.5	50.	22.5	-0.11	-0.73	16.	slightly cool, acceptable
9.3	20.1	14.4	50.	23.0	-0.02	-0.64	13.	slightly cool, acceptable
9.7	20.1	14.9	50.	23.2	0.03	-0.59	12.	slightly cool, acceptable
10.0	20.2	15.2	49.	23.4	0.06	-0.56	11.	slightly cool, acceptable
10.3	20.2	15.5	49.	23.5	0.08	-0.54	11.	slightly cool, acceptable
10.7	20.2	15.7	49.	23.6	0.10	-0.52	11.	slightly cool, acceptable
11.0	20.2	15.8	49.	23.7	0.12	-0.51	10.	slightly cool, acceptable

Figure 21a

11.3	20.1	16.0	49.	23.7	0.13	-0.50	10.	comfortable, pleasant
11.7	20.1	16.1	50.	23.8	0.14	-0.48	10.	comfortable, pleasant
12.0	20.1	16.2	50.	23.9	0.16	-0.47	10.	comfortable, pleasant
12.3	20.1	16.3	50.	23.9	0.17	-0.46	9.	comfortable, pleasant
12.7	20.0	16.3	51.	23.9	0.16	-0.47	10.	comfortable, pleasant
13.0	20.0	16.4	51.	24.0	0.17	-0.47	10.	comfortable, pleasant
13.3	20.0	16.4	51.	24.0	0.17	-0.46	9.	comfortable, pleasant
13.7	20.0	16.5	51.	24.0	0.18	-0.46	9.	comfortable, pleasant
14.0	20.0	16.5	51.	24.0	0.18	-0.45	9.	comfortable, pleasant
14.3	20.0	16.5	51.	24.0	0.18	-0.45	9.	comfortable, pleasant
14.7	20.1	16.5	51.	24.1	0.20	-0.44	9.	comfortable, pleasant
15.0	20.1	16.5	51.	24.1	0.20	-0.43	9.	comfortable, pleasant
15.3	20.1	16.5	51.	24.1	0.20	-0.44	9.	comfortable, pleasant
15.7	20.1	16.5	51.	24.1	0.19	-0.44	9.	comfortable, pleasant
16.0	20.0	16.5	51.	24.0	0.18	-0.46	9.	comfortable, pleasant
16.3	20.0	16.4	50.	24.0	0.17	-0.46	9.	comfortable, pleasant
16.7	20.0	16.4	50.	23.9	0.16	-0.47	10.	comfortable, pleasant
17.0	20.0	16.4	50.	23.9	0.16	-0.47	10.	unoccupied
17.3	19.9	16.4	51.	23.9	0.15	-0.48	10.	unoccupied
17.7	17.4	16.1	58.	22.8	-0.07	-0.75	17.	unoccupied
18.0	15.1	15.7	66.	21.8	-0.30	-1.03	27.	unoccupied
18.3	14.4	15.2	68.	21.4	-0.41	-1.15	33.	unoccupied
18.7	13.2	14.7	72.	20.7	-0.57	-1.34	42.	unoccupied
19.0	12.6	14.2	74.	20.3	-0.66	-1.44	48.	unoccupied
19.3	12.5	13.8	75.	20.1	-0.70	-1.48	50.	unoccupied
19.7	12.4	13.5	76.	19.9	-0.73	-1.52	52.	unoccupied
20.0	12.2	13.3	78.	19.7	-0.77	-1.56	54.	unoccupied
20.3	12.1	13.1	79.	19.6	-0.80	-1.59	56.	unoccupied
20.7	11.9	12.9	81.	19.5	-0.83	-1.62	58.	unoccupied
21.0	11.8	12.8	81.	19.4	-0.85	-1.64	59.	unoccupied
21.3	11.8	12.7	82.	19.3	-0.86	-1.66	60.	unoccupied
21.7	11.7	12.6	83.	19.3	-0.87	-1.67	60.	unoccupied
22.0	11.7	12.5	83.	19.2	-0.89	-1.68	61.	unoccupied
22.3	11.6	12.4	83.	19.2	-0.90	-1.70	62.	unoccupied
22.7	11.5	12.3	83.	19.1	-0.91	-1.71	62.	unoccupied
23.0	11.4	12.3	83.	19.0	-0.93	-1.73	63.	unoccupied
23.3	11.3	12.2	83.	19.0	-0.94	-1.75	64.	unoccupied
23.7	11.3	12.1	83.	18.9	-0.96	-1.77	65.	unoccupied
24.0	11.2	12.1	83.	18.9	-0.97	-1.78	66.	unoccupied

Figure 21b

5.4.3 Changing the climate conditions

By changing the climate conditions and the site on which the building is placed, it is possible to test how simulation tools take into account alternative climate data again producing the new results automatically.

A new, more realistic and standardised, climate file (*milan.clm*) was used in this case and the building's site latitude and longitude difference were changed to align with that of Milan. As Figure 22 shows, the site latitude was changed to 45.46 degrees and the longitude difference to -5.83 degrees. A new simulation was run for this new data and new results (Figures 23, 24, 25a & 25b) were produced. From these results and from the differences with those previously produced, it is shown that dynamic simulation can be used to test the performance of similar buildings in different parts of the world. With regard to the Directive, this may have particular reference e.g. with setting Buildings Standards of performance for different countries in the EU.

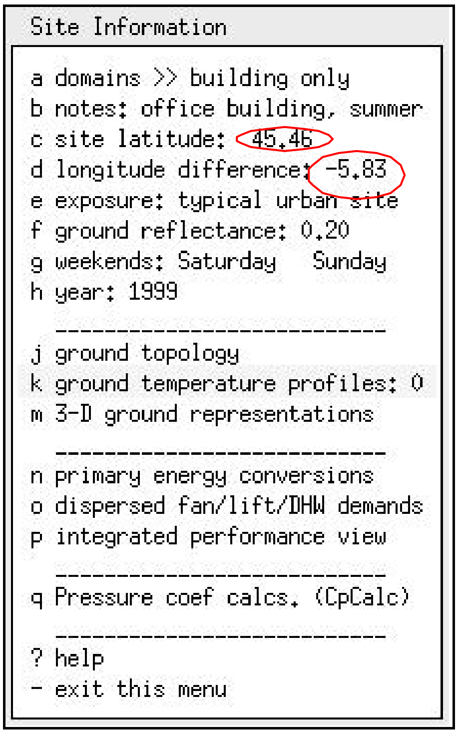


Figure 22

id	Zone name	Sensible heating Energy (kWhrs)	No. of Hr rqd
1	corid_1	111.70	81.7
2	corid_g	459.61	155.3
3	Unit_f	619.15	186.0
4	Unit_g	507.09	165.3
5	Unit_j	2142.49	184.0
6	Unit_a	2905.99	211.0
7	Unit_b	368.77	120.0
8	Unit_e	2907.94	207.7
9	Unit_hi	1604.75	139.7
10	Unit_cd	1211.48	122.0
11	ceil_fg	0.00	0.0
12	ceil_chi	0.00	0.0
13	ceil_j	0.00	0.0
14	stair_abfg	9.97	75.3
15	stair_deij	13.08	62.7
16	toilets	103.69	75.3
17	roof	0.00	0.0
	All	12965.70	

Figure 23

Period: Tue 2 Feb @00h50 to: Thu 18 Feb @23h50 Year:1999 : sim@ 20m, output@ 20m
Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	6.68	8 Feb@08h30	0.00	2 Feb@00h10	0.27	0.88
corid_g	11.07	6 Feb@18h50	0.00	2 Feb@00h10	1.13	2.01
Unit_f	14.94	5 Feb@08h09	0.00	2 Feb@00h10	1.52	2.84
Unit_g	10.76	5 Feb@08h09	0.00	2 Feb@00h10	1.24	2.13
Unit_j	46.87	6 Feb@18h50	0.00	2 Feb@00h10	5.25	9.09
Unit_a	40.08	9 Feb@10h10	0.00	2 Feb@00h10	7.12	9.35
Unit_b	12.07	8 Feb@08h10	0.00	2 Feb@00h10	0.90	2.21
Unit_e	45.79	6 Feb@18h50	0.00	2 Feb@00h10	7.13	9.75
Unit_hi	25.31	15 Feb@08h50	0.00	2 Feb@00h10	3.93	6.35
Unit_cd	28.79	8 Feb@08h10	0.00	2 Feb@00h10	2.97	5.78
ceil_fg	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_chi	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_j	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
stair_abfg	0.49	8 Feb@06h49	0.00	2 Feb@00h10	0.02	0.07
stair_deij	0.70	16 Feb@00h50	0.00	2 Feb@00h10	0.03	0.10
toilets	7.06	8 Feb@08h10	0.00	2 Feb@00h10	0.25	0.89
roof	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
All	196.51	9 Feb@08h30	0.00	2 Feb@00h00		

Figure 24

Note: PMV is Fanger predicted mean vote. PMV* is predicted mean vote based on ET rather then TO.

Comfort assessment for Unit_f on Day 2 of month 2

Activity level 58.20, Clothing level 1.50, Air speed 0.10
Default mean radiant temperature

Time (hrs)	t-air (deg.C)	t-mrt (deg.C)	rel.h (%)	SET (deg.C)	PMV* (-)	PMV (-)	PPD (%)	Comfort assessment based on PMV
0.3	7.5	9.3	53.	16.2	-1.66	-2.60	95.	unoccupied
0.7	7.3	9.1	52.	16.1	-1.69	-2.63	96.	unoccupied
1.0	7.2	9.0	51.	16.0	-1.72	-2.66	96.	unoccupied
1.3	7.1	8.9	51.	15.9	-1.74	-2.69	97.	unoccupied
1.7	7.0	8.8	50.	15.9	-1.76	-2.70	97.	unoccupied
2.0	6.9	8.7	49.	15.8	-1.77	-2.72	97.	unoccupied
2.3	6.8	8.7	49.	15.7	-1.79	-2.74	97.	unoccupied
2.7	6.7	8.6	49.	15.7	-1.80	-2.76	97.	unoccupied
3.0	6.7	8.5	48.	15.6	-1.82	-2.77	98.	unoccupied
3.3	6.6	8.4	48.	15.6	-1.83	-2.79	98.	unoccupied
3.7	6.5	8.4	47.	15.5	-1.84	-2.80	98.	unoccupied
4.0	6.5	8.3	47.	15.5	-1.85	-2.81	98.	unoccupied
4.3	6.4	8.3	47.	15.4	-1.86	-2.83	98.	unoccupied
4.7	6.4	8.2	47.	15.4	-1.87	-2.84	98.	unoccupied
5.0	6.4	8.1	47.	15.4	-1.88	-2.85	98.	unoccupied
5.3	6.3	8.1	47.	15.3	-1.88	-2.85	98.	unoccupied
5.7	6.3	8.1	47.	15.3	-1.89	-2.86	98.	unoccupied
6.0	6.3	8.0	48.	15.3	-1.89	-2.86	98.	unoccupied
6.3	6.3	8.0	48.	15.3	-1.89	-2.87	98.	unoccupied
6.7	6.3	7.9	49.	15.3	-1.89	-2.87	98.	unoccupied
7.0	6.3	7.9	49.	15.3	-1.89	-2.86	98.	unoccupied
7.3	6.3	7.9	50.	15.3	-1.89	-2.86	98.	unoccupied
7.7	6.4	7.9	51.	15.3	-1.89	-2.85	98.	unoccupied
8.0	6.5	7.9	52.	15.3	-1.87	-2.84	98.	cold, shivering
8.3	13.3	8.8	35.	18.0	-1.22	-2.00	77.	cool, unpleasant
8.7	20.8	10.5	24.	21.2	-0.46	-1.07	29.	cool, unpleasant
9.0	20.8	12.3	27.	22.0	-0.28	-0.90	22.	cool, unpleasant
9.3	21.3	13.7	28.	22.9	-0.10	-0.72	16.	slightly cool, acceptable
9.7	21.3	14.5	29.	23.2	-0.02	-0.63	13.	slightly cool, acceptable
10.0	20.3	14.8	33.	23.1	-0.05	-0.68	15.	slightly cool, acceptable
10.3	20.3	15.1	34.	23.2	-0.02	-0.65	14.	slightly cool, acceptable
10.7	20.2	15.3	36.	23.3	0.00	-0.63	13.	slightly cool, acceptable
11.0	20.2	15.5	37.	23.4	0.03	-0.60	13.	slightly cool, acceptable
11.3	20.4	15.7	39.	23.6	0.06	-0.56	12.	slightly cool, acceptable
11.7	20.4	15.8	40.	23.6	0.09	-0.54	11.	slightly cool, acceptable
12.0	20.0	15.9	42.	23.6	0.07	-0.56	12.	slightly cool, acceptable
12.3	20.0	16.0	42.	23.6	0.08	-0.56	11.	slightly cool, acceptable
12.7	20.0	16.0	43.	23.6	0.08	-0.55	11.	slightly cool, acceptable
13.0	20.0	16.1	43.	23.6	0.09	-0.55	11.	slightly cool, acceptable
13.3	20.1	16.2	43.	23.7	0.10	-0.53	11.	slightly cool, acceptable
13.7	20.1	16.3	43.	23.8	0.12	-0.51	10.	slightly cool, acceptable
14.0	20.1	16.5	44.	24.0	0.15	-0.48	10.	comfortable, pleasant
14.3	20.1	16.7	45.	24.1	0.18	-0.46	9.	comfortable, pleasant

Figure 25a

14.7	20.0	16.8	47.	24.1	0.19	-0.45	9.	comfortable, pleasant
15.0	20.0	17.0	47.	24.2	0.21	-0.43	9.	comfortable, pleasant
15.3	20.0	17.1	47.	24.3	0.23	-0.41	9.	comfortable, pleasant
15.7	20.0	17.3	47.	24.4	0.24	-0.40	8.	comfortable, pleasant
16.0	20.0	17.3	47.	24.4	0.24	-0.40	8.	comfortable, pleasant
16.3	20.0	17.4	46.	24.4	0.24	-0.40	8.	comfortable, pleasant
16.7	20.0	17.3	46.	24.4	0.23	-0.41	9.	comfortable, pleasant
17.0	20.0	17.1	46.	24.2	0.21	-0.43	9.	unoccupied
17.3	19.7	16.7	47.	23.9	0.14	-0.50	10.	unoccupied
17.7	18.6	16.3	50.	23.3	0.02	-0.64	14.	unoccupied
18.0	17.6	15.9	53.	22.7	-0.11	-0.79	18.	unoccupied
18.3	16.4	15.3	56.	22.1	-0.25	-0.96	24.	unoccupied
18.7	14.6	14.6	60.	21.1	-0.48	-1.22	36.	unoccupied
19.0	12.9	14.0	64.	20.2	-0.68	-1.46	49.	unoccupied
19.3	12.0	13.4	65.	19.6	-0.83	-1.64	58.	unoccupied
19.7	11.4	12.8	64.	19.2	-0.93	-1.75	65.	unoccupied
20.0	11.0	12.4	64.	18.8	-1.02	-1.85	70.	unoccupied
20.3	10.6	12.0	63.	18.5	-1.09	-1.94	74.	unoccupied
20.7	10.2	11.7	63.	18.2	-1.16	-2.02	78.	unoccupied
21.0	9.9	11.4	62.	18.0	-1.22	-2.09	80.	unoccupied
21.3	9.6	11.1	62.	17.8	-1.27	-2.15	83.	unoccupied
21.7	9.3	10.9	61.	17.6	-1.32	-2.20	85.	unoccupied
22.0	9.2	10.7	60.	17.5	-1.36	-2.24	86.	unoccupied
22.3	9.0	10.5	60.	17.3	-1.39	-2.28	88.	unoccupied
22.7	8.8	10.4	59.	17.2	-1.42	-2.31	89.	unoccupied
23.0	8.7	10.2	59.	17.1	-1.44	-2.34	89.	unoccupied
23.3	8.6	10.1	59.	17.0	-1.47	-2.37	90.	unoccupied
23.7	8.5	10.0	59.	16.9	-1.49	-2.39	91.	unoccupied
24.0	8.4	9.9	59.	16.9	-1.50	-2.41	91.	unoccupied

Figure 25b

5.4.4 Changing the orientation of the building

By keeping the same climate data (*milan.clm)* as before, a change at the orientation of the building was studied to investigate whether or not if ESP-r could also integrate the effect of this in addition to the others previously examined.

All the zones of the building and totally the building was rotated by 90^o anticlockwise about the site origin X=0, Y=0. Thus, ESP-r provides differenet rotation choices and there is flexibility to rotate a zone even around a specific point. After the simulation of this model, new results were again immediately produced by ESP-r purely based on a change in orientation of the building. It should be noted that other than by simulation this process would take much longer to undertake. However, as can be seen from the results (Figures 26, 27 28a & 28b) it is possible to ascertain the "best" position for the building with regard to energy performance. For example, it is evident that the building has less energy requirement after the rotation than before (12966 kWh of sensible energy before the rotation and 11835 kWh after).

Again with regard to the Directive, this could be used to optimise performance.

Zone id	Zone name	Sensible heating Energy (kWhrs)	Sensible heating No. of Hr rqd
1	corid_1	62.17	44.0
2	corid_g	296.05	111.7
3	Unit_f	475.44	133.7
4	Unit_g	467.29	163.7
5	Unit_j	2146.24	191.0
6	Unit_a	2653.37	206.0
7	Unit_b	330.13	88.3
8	Unit_e	2871.82	207.3
9	Unit_hi	1366.02	127.3
10	Unit_cd	1076.40	121.3
11	ceil_fg	0.00	0.0
12	ceil_chi	0.00	0.0
13	ceil_j	0.00	0.0
14	stair_abfg	5.69	49.3
15	stair_deij	10.25	51.0
16	toilets	73.97	45.3
17	roof	0.00	0.0
	All	11834.85	

Figure 26

Period: Tue 2 Feb @00h50 to: Thu 18 Feb @23h50 Year:1999 : sim@ 20m, output@ 20m
Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	5.94	15 Feb@08h30	0.00	2 Feb@00h10	0.15	0.69
corid_g	9.98	6 Feb@18h50	0.00	2 Feb@00h10	0.73	1.66
Unit_f	14.49	15 Feb@08h09	0.00	2 Feb@00h10	1.17	2.70
Unit_g	10.49	15 Feb@08h09	0.00	2 Feb@00h10	1.15	2.11
Unit_j	46.96	6 Feb@18h50	0.00	2 Feb@00h10	5.26	9.08
Unit_a	38.75	9 Feb@10h10	0.00	2 Feb@00h10	6.50	8.94
Unit_b	11.66	8 Feb@08h10	0.00	2 Feb@00h10	0.81	2.15
Unit_e	45.56	6 Feb@18h50	0.00	2 Feb@00h10	7.04	9.63
Unit_hi	23.51	15 Feb@08h50	0.00	2 Feb@00h10	3.35	5.75
Unit_cd	27.35	8 Feb@08h10	0.00	2 Feb@00h10	2.64	5.48
ceil_fg	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_chi	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_j	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
stair_abfg	0.38	8 Feb@07h30	0.00	2 Feb@00h10	0.01	0.05
stair_deij	0.68	16 Feb@00h50	0.00	2 Feb@00h10	0.03	0.09
toilets	6.55	16 Feb@08h09	0.00	2 Feb@00h10	0.18	0.77
roof	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
All	184.96	9 Feb@08h30	0.00	2 Feb@00h00		

Figure 27

Note: PMV is Fanger predicted mean vote. PMV* is predicted mean vote based on ET rather then TO.

Comfort assessment for Unit_f on Day 2 of month 2

Activity level 58.20, Clothing level 1.50, Air speed 0.10
Default mean radiant temperature

Time (hrs)	t-air (deg.C)	t-mrt (deg.C)	rel.h (%)	SET (deg.C)	PMV* (-)	PMV (-)	PPD (%)	Comfort assessment based on PMV
0.3	8.0	9.9	51.	16.7	-1.56	-2.49	93.	unoccupied
0.7	7.8	9.8	50.	16.5	-1.60	-2.52	94.	unoccupied
1.0	7.6	9.6	49.	16.4	-1.62	-2.55	94.	unoccupied
1.3	7.5	9.5	49.	16.3	-1.65	-2.58	95.	unoccupied
1.7	7.5	9.4	48.	16.3	-1.66	-2.60	95.	unoccupied
2.0	7.4	9.3	48.	16.2	-1.68	-2.62	96.	unoccupied
2.3	7.3	9.2	47.	16.2	-1.69	-2.63	96.	unoccupied
2.7	7.2	9.2	47.	16.1	-1.71	-2.65	96.	unoccupied
3.0	7.1	9.1	46.	16.0	-1.73	-2.67	96.	unoccupied
3.3	7.1	9.0	46.	16.0	-1.74	-2.69	97.	unoccupied
3.7	7.0	8.9	46.	15.9	-1.75	-2.70	97.	unoccupied
4.0	6.9	8.9	46.	15.9	-1.77	-2.72	97.	unoccupied
4.3	6.9	8.8	45.	15.8	-1.78	-2.73	97.	unoccupied
4.7	6.8	8.7	45.	15.8	-1.79	-2.74	97.	unoccupied
5.0	6.8	8.7	45.	15.7	-1.80	-2.75	97.	unoccupied
5.3	6.8	8.6	46.	15.7	-1.80	-2.76	97.	unoccupied
5.7	6.7	8.6	46.	15.7	-1.81	-2.76	97.	unoccupied
6.0	6.7	8.5	46.	15.7	-1.81	-2.77	98.	unoccupied

Figure 28a

6.3	6.7	8.5	47.	15.6	-1.82	-2.77	98.	unoccupied
6.7	6.7	8.5	47.	15.6	-1.82	-2.77	98.	unoccupied
7.0	6.7	8.4	48.	15.6	-1.82	-2.77	98.	unoccupied
7.3	6.8	8.4	49.	15.6	-1.82	-2.77	98.	unoccupied
7.7	6.8	8.4	50.	15.6	-1.81	-2.76	97.	unoccupied
8.0	6.9	8.4	51.	15.7	-1.80	-2.75	97.	cold, shivering
8.3	13.5	9.3	35.	18.3	-1.16	-1.93	74.	cool, unpleasant
8.7	21.1	11.0	24.	21.5	-0.39	-1.00	26.	cool, unpleasant
9.0	21.1	12.8	26.	22.4	-0.21	-0.83	19.	cool, unpleasant
9.3	21.3	14.2	28.	23.1	-0.05	-0.67	14.	slightly cool, acceptable
9.7	21.3	15.1	29.	23.5	0.03	-0.58	12.	slightly cool, acceptable
10.0	20.3	15.5	33.	23.4	0.01	-0.62	13.	slightly cool, acceptable
10.3	20.3	15.9	34.	23.6	0.05	-0.58	12.	slightly cool, acceptable
10.7	20.3	16.3	36.	23.8	0.10	-0.53	11.	slightly cool, acceptable
11.0	20.3	16.7	37.	24.0	0.15	-0.49	10.	comfortable, pleasant
11.3	20.3	17.0	39.	24.2	0.19	-0.45	9.	comfortable, pleasant
11.7	20.3	17.3	41.	24.4	0.23	-0.41	9.	comfortable, pleasant
12.0	20.0	17.6	42.	24.5	0.24	-0.40	8.	comfortable, pleasant
12.3	20.0	17.9	43.	24.6	0.27	-0.37	8.	comfortable, pleasant
12.7	20.1	18.1	42.	24.7	0.31	-0.34	7.	comfortable, pleasant
13.0	20.4	18.3	42.	24.9	0.35	-0.30	7.	comfortable, pleasant
13.3	20.7	18.5	41.	25.2	0.40	-0.24	6.	comfortable, pleasant
13.7	21.1	18.8	41.	25.5	0.46	-0.17	6.	comfortable, pleasant
14.0	21.4	19.1	42.	25.7	0.53	-0.11	5.	comfortable, pleasant
14.3	21.5	19.4	42.	25.9	0.57	-0.07	5.	comfortable, pleasant
14.7	21.5	19.6	42.	26.0	0.59	-0.04	5.	comfortable, pleasant
15.0	21.5	19.8	42.	26.1	0.62	-0.02	5.	comfortable, pleasant
15.3	21.7	20.0	41.	26.3	0.64	0.00	5.	comfortable, pleasant
15.7	21.8	20.1	40.	26.4	0.66	0.03	5.	comfortable, pleasant
16.0	21.8	20.2	40.	26.4	0.66	0.04	5.	comfortable, pleasant
16.3	21.8	20.1	39.	26.3	0.65	0.03	5.	comfortable, pleasant
16.7	21.6	19.9	40.	26.2	0.62	-0.02	5.	comfortable, pleasant
17.0	21.2	19.3	41.	25.8	0.53	-0.11	5.	unoccupied
17.3	20.6	18.6	43.	25.2	0.40	-0.25	6.	unoccupied
17.7	19.7	17.8	45.	24.5	0.26	-0.39	8.	unoccupied
18.0	18.9	17.2	48.	23.8	0.11	-0.54	11.	unoccupied
18.3	17.5	16.5	51.	23.0	-0.06	-0.74	17.	unoccupied
18.7	15.5	15.8	56.	21.9	-0.30	-1.03	27.	unoccupied
19.0	13.7	15.0	59.	20.9	-0.53	-1.29	40.	unoccupied
19.3	12.8	14.4	60.	20.3	-0.68	-1.46	49.	unoccupied
19.7	12.2	13.8	60.	19.9	-0.78	-1.58	55.	unoccupied
20.0	11.8	13.3	60.	19.5	-0.87	-1.68	61.	unoccupied
20.3	11.3	12.9	59.	19.1	-0.95	-1.78	66.	unoccupied
20.7	10.9	12.5	59.	18.8	-1.03	-1.87	70.	unoccupied
21.0	10.6	12.2	59.	18.6	-1.09	-1.94	74.	unoccupied
21.3	10.2	11.9	58.	18.3	-1.15	-2.01	77.	unoccupied
21.7	10.0	11.7	58.	18.1	-1.20	-2.06	79.	unoccupied
22.0	9.8	11.4	57.	18.0	-1.24	-2.11	81.	unoccupied
22.3	9.6	11.3	57.	17.8	-1.27	-2.15	83.	unoccupied
22.7	9.4	11.1	57.	17.7	-1.30	-2.18	84.	unoccupied
23.0	9.3	10.9	56.	17.6	-1.33	-2.21	85.	unoccupied
23.3	9.2	10.8	56.	17.5	-1.36	-2.24	86.	unoccupied
23.7	9.1	10.7	56.	17.4	-1.38	-2.27	87.	unoccupied
24.0	9.0	10.6	56.	17.3	-1.40	-2.29	88.	unoccupied

Figure 28b

5.4.5 Changing the air tightness of the building

In the original case study, a network air flow file[*] was used. This option cancels this, and a new control via the operation file was set up to control the air flow. Different air flow control strategies can be set up for infiltration and ventilation using similar simple processes as those for the heating control strategies which were described previously. Figure 29 shows an example, which is described in the operation file, of the air flow control strategy for one of the zones (office space - *Unit_f* zone). The integration of this energy performance aspect with other aspects of the building is apparent from the differences in the new results (Figures 30, 31 32a & 32b) that were produced after running a simulation for this model.

Again, with regard to the Directive, simulation of air tightness sensitivity could be used to aid the development of various EU country Building Standards.

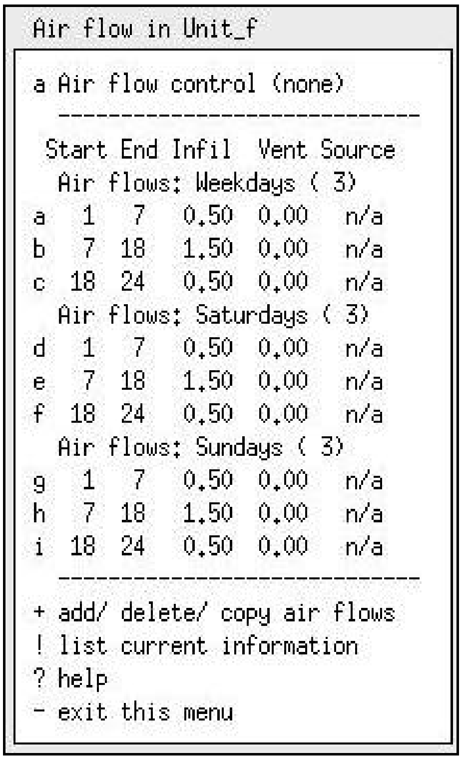


Figure 29

[*] It is possible to schedule air flowing from the outside (infiltration) and from specified zones or plant components (ventilation). This is sometimes approptiate at an early design stage and for flow problems of limited complexity. The flow network approach is based on the use of flow components, representing doors, cracks, ducts, fans, etc. to excplicity represent the distributed leakage for numerical solution. This approach requires significantly more information.

id	Zone name	Sensible heating Energy (kWhrs)	No. of Hr rqd
1	corid_1	82.84	57.3
2	corid_g	89.61	68.3
3	Unit_f	887.36	186.7
4	Unit_g	395.66	171.7
5	Unit_j	807.04	182.0
6	Unit_a	763.81	145.0
7	Unit_b	309.87	105.7
8	Unit_e	715.84	148.0
9	Unit_hi	1620.20	149.7
10	Unit_cd	1449.62	127.3
11	ceil_fg	0.00	0.0
12	ceil_chi	0.00	0.0
13	ceil_j	0.00	0.0
14	stair_abfg	15.69	103.3
15	stair_deij	16.53	106.0
16	toilets	116.23	131.7
17	roof	0.00	0.0
	All	7270.32	

Figure 30

Period: Tue 2 Feb @00h50 to: Thu 18 Feb @23h50 Year:1999 : sim@ 20m, output@ 20m
Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	5.20	15 Feb@08h50	0.00	2 Feb@00h10	0.20	0.67
corid_g	4.45	15 Feb@08h50	0.00	2 Feb@00h10	0.22	0.65
Unit_f	19.20	8 Feb@08h10	0.00	2 Feb@00h10	2.17	3.98
Unit_g	9.94	8 Feb@08h10	0.00	2 Feb@00h10	0.97	1.84
Unit_j	18.36	8 Feb@08h10	0.00	2 Feb@00h10	1.98	3.73
Unit_a	19.82	15 Feb@08h50	0.00	2 Feb@00h10	1.87	3.97
Unit_b	11.79	8 Feb@08h10	0.00	2 Feb@00h10	0.76	1.95
Unit_e	19.74	15 Feb@08h50	0.00	2 Feb@00h10	1.75	3.72
Unit_hi	25.90	8 Feb@08h10	0.00	2 Feb@00h10	3.97	6.65
Unit_cd	32.16	8 Feb@08h30	0.00	2 Feb@00h10	3.55	6.74
ceil_fg	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_chi	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_j	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
stair_abfg	0.45	8 Feb@07h10	0.00	2 Feb@00h10	0.04	0.09
stair_deij	0.47	8 Feb@06h49	0.00	2 Feb@00h10	0.04	0.09
toilets	3.51	8 Feb@08h10	0.00	2 Feb@00h10	0.28	0.60
roof	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
All	164.48	8 Feb@08h30	0.00	2 Feb@00h00		

Figure 31

Note: PMV is Fanger predicted mean vote. PMV* is predicted mean vote based on ET rather then TO.

Comfort assessment for Unit_f on Day 2 of month 2

Activity level 58.20, Clothing level 1.50, Air speed 0.10
Default mean radiant temperature

Time (hrs)	t-air (deg.C)	t-mrt (deg.C)	rel.h (%)	SET (deg.C)	PMV* (-)	PMV (-)	PPD (%)	Comfort assessment based on PMV
0.3	8.6	10.1	50.	17.0	-1.49	-2.40	91.	unoccupied
0.7	8.7	10.0	49.	17.0	-1.49	-2.39	91.	unoccupied
1.0	9.1	10.0	47.	17.1	-1.46	-2.35	90.	unoccupied
1.3	9.3	10.0	47.	17.2	-1.44	-2.32	89.	unoccupied
1.7	9.2	10.0	47.	17.1	-1.46	-2.34	89.	unoccupied
2.0	8.6	9.9	48.	16.9	-1.51	-2.41	91.	unoccupied
2.3	8.2	9.8	48.	16.7	-1.56	-2.48	93.	unoccupied
2.7	8.0	9.7	48.	16.6	-1.59	-2.51	94.	unoccupied
3.0	7.9	9.6	47.	16.5	-1.61	-2.53	94.	unoccupied
3.3	7.8	9.5	47.	16.4	-1.63	-2.55	94.	unoccupied
3.7	7.7	9.4	46.	16.4	-1.64	-2.57	95.	unoccupied
4.0	7.6	9.3	46.	16.3	-1.66	-2.59	95.	unoccupied
4.3	7.6	9.3	46.	16.2	-1.67	-2.60	95.	unoccupied
4.7	7.5	9.2	45.	16.2	-1.68	-2.62	96.	unoccupied
5.0	7.5	9.1	45.	16.2	-1.69	-2.63	96.	unoccupied
5.3	7.4	9.1	45.	16.1	-1.70	-2.64	96.	unoccupied
5.7	7.4	9.0	45.	16.1	-1.71	-2.64	96.	unoccupied
6.0	7.4	9.0	45.	16.1	-1.71	-2.65	96.	unoccupied
6.3	7.4	9.0	46.	16.0	-1.72	-2.65	96.	unoccupied
6.7	7.3	8.9	46.	16.0	-1.72	-2.66	96.	unoccupied
7.0	7.3	8.9	47.	16.0	-1.72	-2.66	96.	unoccupied
7.3	7.2	8.9	48.	16.0	-1.74	-2.68	96.	unoccupied
7.7	6.8	8.8	50.	15.8	-1.78	-2.73	97.	unoccupied
8.0	6.3	8.7	54.	15.6	-1.82	-2.79	98.	cold, shivering
8.3	13.0	9.5	37.	18.2	-1.17	-1.95	74.	cool, unpleasant
8.7	20.5	11.3	25.	21.5	-0.41	-1.03	27.	cool, unpleasant
9.0	20.5	12.9	27.	22.2	-0.24	-0.87	21.	cool, unpleasant
9.3	21.1	14.3	27.	23.1	-0.06	-0.67	15.	slightly cool, acceptable
9.7	21.1	15.2	28.	23.5	0.03	-0.59	12.	slightly cool, acceptable
10.0	20.4	15.7	30.	23.5	0.03	-0.60	13.	slightly cool, acceptable
10.3	20.4	16.1	31.	23.7	0.07	-0.56	12.	slightly cool, acceptable
10.7	20.3	16.5	32.	23.9	0.10	-0.54	11.	slightly cool, acceptable
11.0	20.3	16.9	33.	24.1	0.14	-0.50	10.	comfortable, pleasant
11.3	20.2	17.2	34.	24.2	0.17	-0.47	10.	comfortable, pleasant
11.7	20.2	17.5	34.	24.4	0.21	-0.44	9.	comfortable, pleasant
12.0	20.2	17.8	35.	24.6	0.24	-0.40	8.	comfortable, pleasant
12.3	20.2	18.1	35.	24.7	0.27	-0.37	8.	comfortable, pleasant
12.7	20.2	18.3	36.	24.8	0.29	-0.35	8.	comfortable, pleasant
13.0	20.2	18.5	36.	24.9	0.31	-0.33	7.	comfortable, pleasant
13.3	20.2	18.7	36.	25.0	0.33	-0.32	7.	comfortable, pleasant
13.7	20.2	18.9	36.	25.1	0.35	-0.30	7.	comfortable, pleasant
14.0	20.2	19.1	36.	25.2	0.37	-0.28	7.	comfortable, pleasant
14.3	20.2	19.3	36.	25.2	0.38	-0.26	6.	comfortable, pleasant
14.7	20.2	19.5	35.	25.3	0.40	-0.25	6.	comfortable, pleasant
15.0	20.2	19.6	35.	25.4	0.41	-0.24	6.	comfortable, pleasant
15.3	20.1	19.8	34.	25.4	0.42	-0.23	6.	comfortable, pleasant
15.7	20.2	19.9	34.	25.5	0.43	-0.22	6.	comfortable, pleasant
16.0	20.2	19.9	34.	25.5	0.43	-0.22	6.	comfortable, pleasant
16.3	20.1	19.8	34.	25.4	0.41	-0.24	6.	comfortable, pleasant
16.7	20.0	19.6	35.	25.3	0.39	-0.26	6.	comfortable, pleasant
17.0	20.0	19.0	35.	25.0	0.34	-0.31	7.	unoccupied
17.3	19.4	18.3	37.	24.5	0.22	-0.44	9.	unoccupied
17.7	17.8	17.5	42.	23.5	0.02	-0.66	14.	unoccupied
18.0	16.2	16.8	46.	22.6	-0.17	-0.88	22.	unoccupied
18.3	14.7	16.1	51.	21.7	-0.36	-1.11	31.	unoccupied
18.7	13.3	15.3	54.	20.9	-0.56	-1.34	43.	unoccupied
19.0	12.7	14.6	55.	20.3	-0.68	-1.48	50.	unoccupied

Figure 32a

19.3	12.6	14.0	54.	20.1	-0.74	-1.53	53.	unoccupied
19.7	12.3	13.6	54.	19.8	-0.80	-1.61	57.	unoccupied
20.0	11.9	13.2	55.	19.5	-0.88	-1.69	61.	unoccupied
20.3	11.5	12.9	55.	19.2	-0.95	-1.77	66.	unoccupied
20.7	11.2	12.6	56.	18.9	-1.01	-1.84	69.	unoccupied
21.0	10.9	12.3	56.	18.7	-1.06	-1.90	72.	unoccupied
21.3	10.6	12.1	56.	18.5	-1.11	-1.95	75.	unoccupied
21.7	10.4	11.9	56.	18.4	-1.15	-2.00	77.	unoccupied
22.0	10.2	11.7	55.	18.2	-1.18	-2.04	79.	unoccupied
22.3	10.0	11.5	55.	18.1	-1.21	-2.08	80.	unoccupied
22.7	9.9	11.4	55.	18.0	-1.24	-2.11	81.	unoccupied
23.0	9.7	11.2	55.	17.9	-1.27	-2.14	83.	unoccupied
23.3	9.6	11.1	55.	17.8	-1.29	-2.16	84.	unoccupied
23.7	9.5	11.0	55.	17.7	-1.31	-2.18	84.	unoccupied
24.0	9.4	10.9	55.	17.6	-1.33	-2.20	85.	unoccupied

Figure 32b

5.4.6 Changing the occupancy density

Similarly to the air flow, changes to the occupation density were made in the operation files for some zones of the building while retaining all of the previous changes (i.e. building is rotated, climate data for Milan, etc.). It was assumed that 5 more people more would occupy the building on weekdays from 8.00 to 18.00 in the *Unit_f*, *Unit_j*, *Unit_a* and *Unit_e* zones that are used as offices. Each of these people was assumed to be adding 90 W sensible and 50 W latent to the casul gains of these zones (totally for 5 people: 450 W sensible and 250 W for latent casual gains). This change is presented at the Figure 33. By running a simulation after this change, it is apparent from Figures 34, 35 36a & 36b that more casual gains reduce the heating energy requirements.

The significance of this for the Directive could be in optimising the energy performance of buildings, like for example the public buildings that a different number of people are visiting every day.

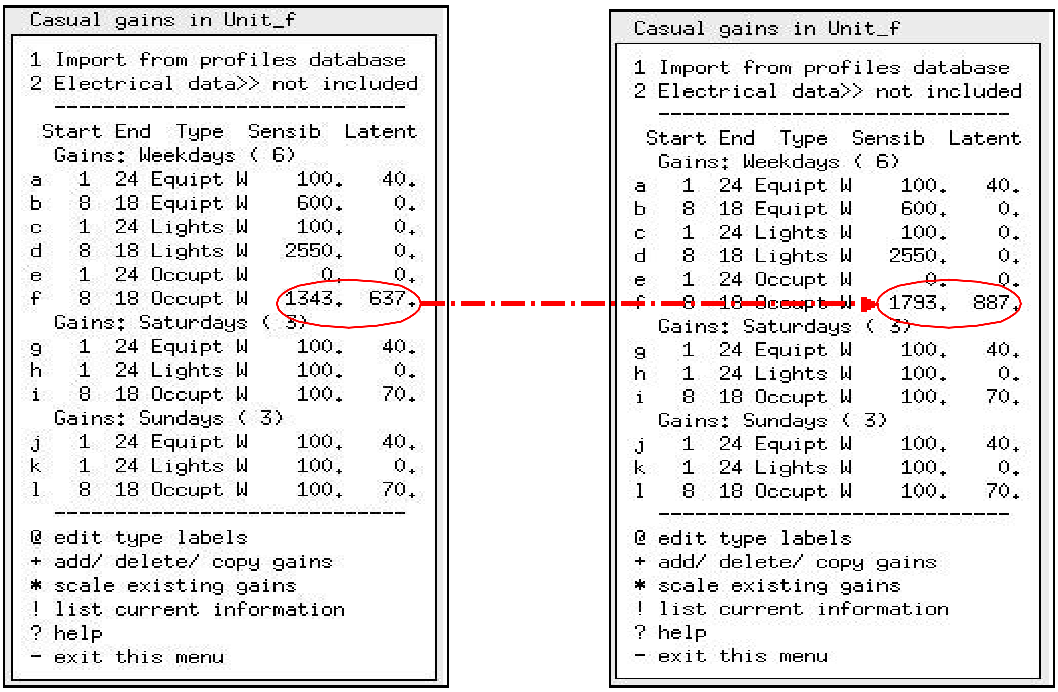


Figure 33

id	Zone name	Sensible heating Energy (kWhrs)	No. of Hr rqd
1	corid_1	82.62	57.3
2	corid_g	89.48	68.3
3	Unit_f	842.02	185.0
4	Unit_g	394.00	170.3
5	Unit_j	760.67	179.7
6	Unit_a	722.53	141.7
7	Unit_b	308.73	104.0
8	Unit_e	672.05	143.3
9	Unit_hi	1619.03	149.7
10	Unit_cd	1446.61	127.3
11	ceil_fg	0.00	0.0
12	ceil_chi	0.00	0.0
13	ceil_j	0.00	0.0
14	stair_abfg	15.53	102.7
15	stair_deij	16.36	104.7
16	toilets	115.79	131.7
17	roof	0.00	0.0
	All	7085.41	

Figures 34

Period: Tue 2 Feb @00h50 to: Thu 18 Feb @23h50 Year:1999 : sim@ 20m, output@ 20m
Zone sensible + latent load (kW)

Description	Maximum value	Maximum occurrence	Minimum value	Minimum occurrence	Mean value	Standard deviation
corid_1	5.20	15 Feb@08h50	0.00	2 Feb@00h10	0.20	0.67
corid_g	4.44	15 Feb@08h50	0.00	2 Feb@00h10	0.22	0.65
Unit_f	19.02	8 Feb@08h10	0.00	2 Feb@00h10	2.06	3.86
Unit_g	9.93	8 Feb@08h10	0.00	2 Feb@00h10	0.97	1.83
Unit_j	18.18	8 Feb@08h10	0.00	2 Feb@00h10	1.86	3.61
Unit_a	19.41	15 Feb@08h50	0.00	2 Feb@00h10	1.77	3.86
Unit_b	11.79	8 Feb@08h10	0.00	2 Feb@00h10	0.76	1.95
Unit_e	19.33	15 Feb@08h50	0.00	2 Feb@00h10	1.65	3.61
Unit_hi	25.90	8 Feb@08h10	0.00	2 Feb@00h10	3.97	6.65
Unit_cd	32.16	8 Feb@08h30	0.00	2 Feb@00h10	3.55	6.73
ceil_fg	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_chi	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
ceil_j	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
stair_abfg	0.45	8 Feb@07h10	0.00	2 Feb@00h10	0.04	0.08
stair_deij	0.47	8 Feb@06h49	0.00	2 Feb@00h10	0.04	0.09
toilets	3.51	8 Feb@08h10	0.00	2 Feb@00h10	0.28	0.60
roof	0.00	2 Feb@00h10	0.00	2 Feb@00h10	0.00	0.00
All	163.52	8 Feb@08h30	0.00	2 Feb@00h00		

Figure 35

Note: PMV is Fanger predicted mean vote. PMV* is predicted mean vote based on ET rather then TO.

Comfort assessment for Unit_f on Day 2 of month 2

Activity level 58.20, Clothing level 1.50, Air speed 0.10
Default mean radiant temperature

Time (hrs)	t-air (deg.C)	t-mrt (deg.C)	rel.h (%)	SET (deg.C)	PMV* (-)	PMV (-)	PPD (%)	Comfort assessment based on PMV
0.3	8.6	10.1	50.	17.0	-1.49	-2.39	91.	unoccupied
0.7	8.7	10.0	49.	17.0	-1.48	-2.38	91.	unoccupied
1.0	9.1	10.0	48.	17.1	-1.46	-2.34	90.	unoccupied
1.3	9.3	10.0	47.	17.2	-1.44	-2.31	89.	unoccupied
1.7	9.2	10.0	47.	17.1	-1.45	-2.34	89.	unoccupied
2.0	8.7	9.9	48.	16.9	-1.51	-2.41	91.	unoccupied
2.3	8.2	9.8	48.	16.7	-1.56	-2.47	93.	unoccupied
2.7	8.0	9.7	48.	16.6	-1.59	-2.51	94.	unoccupied
3.0	7.9	9.6	47.	16.5	-1.61	-2.53	94.	unoccupied
3.3	7.8	9.5	47.	16.4	-1.63	-2.55	94.	unoccupied
3.7	7.7	9.4	46.	16.4	-1.64	-2.57	95.	unoccupied
4.0	7.7	9.3	46.	16.3	-1.66	-2.59	95.	unoccupied
4.3	7.6	9.3	46.	16.3	-1.67	-2.60	95.	unoccupied
4.7	7.5	9.2	45.	16.2	-1.68	-2.61	96.	unoccupied
5.0	7.5	9.2	45.	16.2	-1.69	-2.62	96.	unoccupied
5.3	7.4	9.1	45.	16.1	-1.70	-2.63	96.	unoccupied
5.7	7.4	9.1	45.	16.1	-1.71	-2.64	96.	unoccupied
6.0	7.4	9.0	45.	16.1	-1.71	-2.65	96.	unoccupied
6.3	7.4	9.0	46.	16.1	-1.72	-2.65	96.	unoccupied
6.7	7.4	8.9	46.	16.0	-1.72	-2.66	96.	unoccupied
7.0	7.4	8.9	47.	16.0	-1.72	-2.66	96.	unoccupied
7.3	7.2	8.9	48.	16.0	-1.74	-2.67	96.	unoccupied
7.7	6.8	8.8	50.	15.8	-1.78	-2.73	97.	unoccupied
8.0	6.3	8.7	54.	15.6	-1.82	-2.79	98.	cold, shivering
8.3	13.0	9.6	37.	18.2	-1.16	-1.94	74.	cool, unpleasant
8.7	20.6	11.3	26.	21.5	-0.40	-1.02	27.	cool, unpleasant
9.0	20.6	13.0	28.	22.3	-0.23	-0.85	20.	cool, unpleasant
9.3	21.1	14.4	29.	23.1	-0.05	-0.66	14.	slightly cool, acceptable
9.7	21.1	15.2	30.	23.5	0.04	-0.57	12.	slightly cool, acceptable
10.0	20.4	15.7	32.	23.5	0.04	-0.59	12.	slightly cool, acceptable
10.3	20.4	16.2	33.	23.7	0.09	-0.55	11.	slightly cool, acceptable
10.7	20.3	16.6	34.	23.9	0.11	-0.52	11.	slightly cool, acceptable

Figure 36a

11.0	20.3	16.9	35.	24.1	0.15	-0.48	10.	comfortable, pleasant
11.3	20.2	17.2	36.	24.3	0.19	-0.45	9.	comfortable, pleasant
11.7	20.2	17.5	36.	24.4	0.22	-0.42	9.	comfortable, pleasant
12.0	20.2	17.9	37.	24.6	0.26	-0.39	8.	comfortable, pleasant
12.3	20.2	18.1	37.	24.7	0.29	-0.36	8.	comfortable, pleasant
12.7	20.2	18.4	38.	24.8	0.31	-0.34	7.	comfortable, pleasant
13.0	20.2	18.6	38.	24.9	0.33	-0.32	7.	comfortable, pleasant
13.3	20.2	18.7	38.	25.0	0.34	-0.30	7.	comfortable, pleasant
13.7	20.2	18.9	38.	25.1	0.36	-0.28	7.	comfortable, pleasant
14.0	20.2	19.2	38.	25.2	0.38	-0.26	6.	comfortable, pleasant
14.3	20.2	19.3	38.	25.3	0.40	-0.25	6.	comfortable, pleasant
14.7	20.2	19.5	37.	25.4	0.41	-0.24	6.	comfortable, pleasant
15.0	20.3	19.7	36.	25.5	0.44	-0.20	6.	comfortable, pleasant
15.3	20.4	19.9	35.	25.6	0.46	-0.18	6.	comfortable, pleasant
15.7	20.5	20.0	35.	25.7	0.48	-0.16	6.	comfortable, pleasant
16.0	20.5	20.0	35.	25.7	0.48	-0.16	6.	comfortable, pleasant
16.3	20.4	19.9	35.	25.6	0.46	-0.18	6.	comfortable, pleasant
16.7	20.1	19.7	36.	25.4	0.42	-0.23	6.	comfortable, pleasant
17.0	20.0	19.1	37.	25.1	0.36	-0.29	7.	unoccupied
17.3	19.5	18.4	39.	24.6	0.25	-0.41	9.	unoccupied
17.7	18.1	17.6	43.	23.6	0.06	-0.61	13.	unoccupied
18.0	16.6	16.9	48.	22.8	-0.12	-0.82	19.	unoccupied
18.3	15.0	16.2	52.	21.9	-0.32	-1.05	28.	unoccupied
18.7	13.4	15.4	56.	21.0	-0.54	-1.31	41.	unoccupied
19.0	12.7	14.7	56.	20.4	-0.66	-1.46	49.	unoccupied
19.3	12.7	14.1	55.	20.2	-0.72	-1.51	52.	unoccupied
19.7	12.4	13.7	55.	19.9	-0.79	-1.59	56.	unoccupied
20.0	12.0	13.3	56.	19.5	-0.87	-1.68	61.	unoccupied
20.3	11.6	12.9	56.	19.2	-0.94	-1.76	65.	unoccupied
20.7	11.2	12.6	56.	19.0	-1.00	-1.83	68.	unoccupied
21.0	10.9	12.4	56.	18.8	-1.05	-1.89	72.	unoccupied
21.3	10.6	12.1	56.	18.6	-1.10	-1.94	74.	unoccupied
21.7	10.4	11.9	56.	18.4	-1.14	-1.99	76.	unoccupied
22.0	10.2	11.7	56.	18.2	-1.18	-2.03	78.	unoccupied
22.3	10.1	11.5	56.	18.1	-1.21	-2.07	80.	unoccupied
22.7	9.9	11.4	55.	18.0	-1.24	-2.10	81.	unoccupied
23.0	9.8	11.3	55.	17.9	-1.26	-2.13	82.	unoccupied
23.3	9.7	11.1	55.	17.8	-1.28	-2.16	83.	unoccupied
23.7	9.5	11.0	55.	17.7	-1.30	-2.18	84.	unoccupied
24.0	9.5	10.9	55.	17.6	-1.32	-2.20	85.	unoccupied

Figure 36b

5.5 Presentation of Results

Presenting information in the tabular format used so far in this thesis is not always appropriate and or understandable for designers or their clients. In addition to all of the ways that ESP-r and other real-time dynamic simulation tools could be used to approach the aspects of the EU Directive, ESP-r also offers a method of assessing the balance between different aspects of performance compared with one an other.

There is a need to ensure that the costs and benefits of different design options are viewed in the context of a range of issues in order to maintain a balanced response, with one aspect set against another. This balance could for example, be achieved with a mechanism that ensures that the appropriate assessments are run and the relevant performance metrics are extracted in a form that highlights any areas where more detailed study may be required for improvements.

In ESP-r this mechanism is defined as an **Integrated Performance View** (IPV; Figure 37) [Clarke et al 1998]. The Integrated Performance View allows the benefits and the results of the working and reporting procedures to be applied to bespoke project work and then embodied in the workings of an assessment tool. It gives useful results that can lead to early identifications of design problems and supports a compact view of the performance implications of design changes. By embedding this Integrated Performance View within the model it is also possible to replicate a particular assessment at a later date.

There is insufficient information to produce an IPV for the case study but an example is shown in Figure 37.

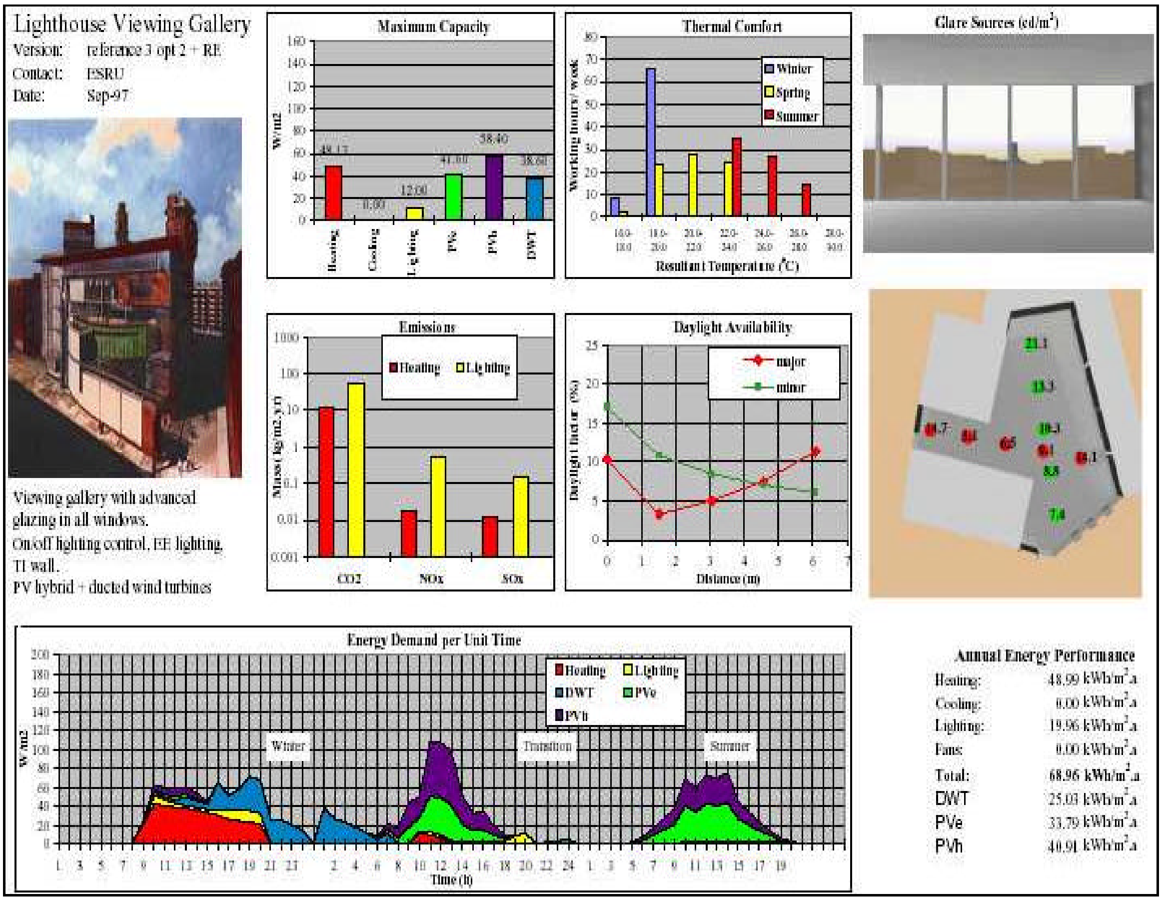

Lighthouse Viewing Gallery
Version: reference 3 opt 2 + RE
Contact: ESRU
Date: Sep-97
Viewing gallery with advanced glazing in all windows.
On/off lighting control, EE lighting.
TI wall.
PV hybrid + ducted wind turbines
Maximum Capacity
Thermal Comfort
Glare Sources (cd/m²)
Emissions
Daylight Availability
Energy Demand per Unit Time
Winter
Transition
Summer
Annual Energy Performance
Heating: 48.99 kWh/m².a
Cooling: 0.00 kWh/m².a
Lighting: 19.96 kWh/m².a
Fans: 0.00 kWh/m².a
Total: 68.96 kWh/m².a
DWT 25.03 kWh/m².a
PVe 33.79 kWh/m².a
PVh 40.91 kWh/m².a

Figure 37

6 Conclusion

The impact of the effects of energy consumption and in particular of the emissions from energy produced from the consumption of fossil fuels is important for the climate, global warming and generally for the sustainable development, in that excessive energy consumption is believed to lead to climate change because of the greenhouse gases that are emitted as a result of energy consumption.

Moreover, a significant amount of energy is consumed by the building sector, and therefore there is a great potential for energy savings in this sector. To take full advantage of these savings, it will be necessary to introduce new conservation measures and associated legislation. In this respect, the European Union has introduced a new Directive for the energy performance of buildings. This is the first time that the energy performance of buildings has been officially introduced as an aspect to be considered in this way. It goes without saying that the intentions, objectives and scope of the Directive are positive and to be welcomed. However, the document does not yet specify the way in which the requirements of this Directive should be addressed. Nevertheless, the Directive proposes that the building aspects concerned with energy performance should be integrated. ***But not how***. This thesis proposed that dynamic integrated simulation could be one way of integrating all of these aspects and that it could cope well with the Directive's requirements. This was examined through a case study that was selected to examine the scope for integration.

A number of possible simulation tools were reviwed. Their suitability for studying the various energy performance aspects that the Directive proposes was assessed. ESP-r was available to the author and therefore was used in this case. Tools vary in approach for purpose but in generally can meet most of the Directive's requirements.

Two key aspects, the thermal insulation and the heating were, analysed in an interrelated simulation by using ESP-r and detailed results were produced for each of these aspects by inserting the appropriate inputs. New results were produced for a senior of changes to each of these two aspects and moreover for the additional changes of climate, orientation, air tightness of the building and occupancy. These changes were simultaneously taken into account by the simulation tool and different results were produced rapidly. A comfort analysis was also produced and again analytical outputs were given by ESP-r to relate the aspect of the indoor air quality with the rest energy performance aspects.

All these results could be very difficult to be calculated in such detail with other ways. However, the study shows that simulation has the flexibility to produce hourly and overall annual performance results. To make information presentation clearer, the approach of the Integrated Performance View that ESP-r produces is proposed as a possible development for all simulation tools if used to address the Directive. The Integrated Performance View option of ESP-r, also offers a clearly presented analysis of all of the aspects relating to the energy performance of buildings. It also offers a comparison technique for the energy performances of different building design options and can provide useful conclusions in a clearly illustrated manner.

However, using simulation to produce all these results and improve the energy performance of the buildings is a complicated process and users have to be trained in these techniques. Despite the steep learning curves, using dynamic simulation is the only reliable way to integrate all of the energy performance aspects involved. Professionals dealing with energy matters in buildings may find it necessary to move up that learning curve by beginning the process of starting to use dynamic simulation tools in order to be ready to meet the challenges of the Comission's new Directive.

This thesis concludes that the available simulation tools can address the requirements of the Directive.

7 Recommendations for future work

Member States should make the minimum standards for the energy performance of buildings and generally the requirements of the Directive, more specific by introducing new legislation. Suggestions and studies should be undertaken with regard to this by also taking into account the energy performance that buildings should have in the future.

Moreover, studies can be undertaken with a view to suggesting more new measures, which will include industrial and existing buildings or which will contribute in to improving the energy performance of a larger number of buildings.

Therefore, proposals should be made for new, novel approaches to both legislate and encourage owners and occupiers to continually improve all the time the energy performance of their buildings in the form of tax deductions, soft credits and generally other economic initiatives.

Additionally, further examination of the Directive and how to address its requirements, could be made in context of more and more appropriate simulation tools.

Also, recommendations could be made for how to modify all simulation tools to address the same key issues.

Finally, in order for professionals to start using the available simulation tools more and to address the Directive's requirements, new methods should be found for managing and deploying (training courses, tutorials, support groups, etc.) these tools within design practice. There is such an initiative in the UK and such an Association world wide – set up to assist with using tools. Simulation tools should be improved and developed to be more "user friendly" bearing in mind that this is difficult due to the complex nature of the tools and the number of aspects that the tools attempt to integrate and analyse.

8 References

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9 Appendices

9.1 Files used for the case study

9.1.1 System Configuration file (.cfg)

```
* CONFIGURATION3.0
# ESRU system configuration defined by file
# office_win.cfg
*date Sat Aug 23 19:07:20 1997  # latest file modification
*root office
*zonpth ../zones                  # path to zones
*netpth ../networks               # path to networks
*ctlpth ../ctl                    # path to controls
*imgpth ../images                 # path to project images
*indx    1 # Building only
 59.000    0.000   # Latitude & Longitude (diff from meridian)
      2   0.200   # Site exposure & ground reflectivity
* DATABASES
*prm  /usr/esru/esp-r/databases/constr.db2
*mlc  /usr/esru/esp-r/databases/multicon.db2
*opt  /usr/esru/esp-r/databases/optics.db2
*prs  /usr/esru/esp-r/databases/pressc.db1
*evn  /usr/esru/esp-r/databases/profiles.db1
*clm  /usr/esru/esp-r/climate/clm67
*pdb  /usr/esru/esp-r/databases/plantc.db1
*ctl  ../ctl/winter4.ctl
*year  1967 # assessment year
*img GIF   FZON  ../images/office_montg.gif
*img GIF   FNET  ../images/office_af.gif
* PROJ LOG
office.log
* Building
office building, winter operation
     17  # no of zones
*zon   1   # reference for corid_1
*opr ../zones/entry.opr  # schedules
*geo ../zones/corid_1.geo  # geometry
*con ../zones/corid_1.con  # construction
*tmc ../zones/corid_1.tmc  # transparent constr
*zend
*zon   2   # reference for corid_g
*opr ../zones/entry.opr  # schedules
*geo ../zones/corid_g.geo  # geometry
*con ../zones/corid_g.con  # construction
*tmc ../zones/corid_g.tmc  # transparent constr
*zend
*zon   3   # reference for Unit_f
*opr ../zones/occup_offices.opr  # schedules
```

```
*geo ../zones/Unit_f.geo  # geometry
*con ../zones/Unit_f.con  # construction
*tmc ../zones/Unit_f.tmc  # transparent constr
*zend
*zon   4   # reference for Unit_g
*opr ../zones/offices_bg.opr  # schedules
*geo ../zones/Unit_g.geo  # geometry
*con ../zones/Unit_g.con  # construction
*tmc ../zones/Unit_g.tmc  # transparent constr
*zend
*zon   5   # reference for Unit_j
*opr ../zones/occup_offices.opr  # schedules
*geo ../zones/Unit_j.geo  # geometry
*con ../zones/Unit_j.con  # construction
*tmc ../zones/Unit_j.tmc  # transparent constr
*zend
*zon   6   # reference for Unit_a
*opr ../zones/occup_offices.opr  # schedules
*geo ../zones/Unit_a.geo  # geometry
*con ../zones/Unit_a.con  # construction
*tmc ../zones/Unit_a.tmc  # transparent constr
*zend
*zon   7   # reference for Unit_b
*opr ../zones/offices_bg.opr  # schedules
*geo ../zones/Unit_b.geo  # geometry
*con ../zones/Unit_b.con  # construction
*tmc ../zones/Unit_b.tmc  # transparent constr
*zend
*zon   8   # reference for Unit_e
*opr ../zones/occup_offices.opr  # schedules
*geo ../zones/Unit_e.geo  # geometry
*con ../zones/Unit_e.con  # construction
*tmc ../zones/Unit_e.tmc  # transparent constr
*zend
*zon   9   # reference for Unit_hi
*opr ../zones/unoccup_offices.opr  # schedules
*geo ../zones/Unit_hi.geo  # geometry
*con ../zones/Unit_hi.con  # construction
*tmc ../zones/Unit_hi.tmc  # transparent constr
*zend
*zon  10   # reference for Unit_cd
*opr ../zones/unoccup_offices.opr  # schedules
*geo ../zones/Unit_cd.geo  # geometry
*con ../zones/Unit_cd.con  # construction
*tmc ../zones/Unit_cd.tmc  # transparent constr
*zend
*zon  11   # reference for ceil_fg
*opr ../zones/ceiling.opr  # schedules
*geo ../zones/ceil_fg.geo  # geometry
*con ../zones/ceil_fg.con  # construction
```

```
*zend
*zon  12   # reference for ceil_chi
*opr ../zones/ceiling.opr  # schedules
*geo ../zones/ceil_chi.geo  # geometry
*con ../zones/ceil_chi.con  # construction
*tmc ../zones/ceil_chi.tmc  # transparent constr
*zend
*zon  13   # reference for ceil_j
*opr ../zones/ceiling.opr  # schedules
*geo ../zones/ceil_j.geo  # geometry
*con ../zones/ceil_j.con  # construction
*zend
*zon  14   # reference for stair_abfg
*opr ../zones/entry.opr  # schedules
*geo ../zones/stair_abfg.geo  # geometry
*con ../zones/stair_abfg.con  # construction
*zend
*zon  15   # reference for stair_deij
*opr ../zones/entry.opr  # schedules
*geo ../zones/stair_deij.geo  # geometry
*con ../zones/stair_deij.con  # construction
*zend
*zon  16   # reference for toilets
*opr ../zones/entry.opr  # schedules
*geo ../zones/toilets.geo  # geometry
*con ../zones/toilets.con  # construction
*zend
*zon  17   # reference for roof
*opr ../zones/roof.opr  # schedules
*geo ../zones/roof.geo  # geometry
*con ../zones/roof.con  # construction
*zend
*cnn  office.cnn  # connections
    1   # fluid flow network:
../networks/winter.afn    # leakage description
  6  5 11 12 14  7  8 10 13  9  0  0  0 15 16 17 18
```

9.1.2 System Control file (.ctl)

```
science park  # overall descr
* Building
winter heating  # bld descr
  3  # No. of functions
* Control function
# senses the temperature of the current zone.
   0    0    0    0  # sensor data
# actuates air point of the current zone
   0    0    0  # actuator data
   0 # No. day types
   1  365  # valid Sun  1 Jan - Sun 31 Dec
    3  # No. of periods in day
   0    2   0.000  # ctl type, law (free floating), start @
     0.  # No. of data items
   0    1   8.000  # ctl type, law (basic control), start @
     7.  # No. of data items
  65000.000 0.000 0.000 0.000 20.000 100.000 0.000
   0    2  17.000  # ctl type, law (free floating), start @
     0.  # No. of data items
   1  365  # valid Sun  1 Jan - Sun 31 Dec
    1  # No. of periods in day
   0    1   0.000  # ctl type, law (basic control), start @
     7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
   1  365  # valid Sun  1 Jan - Sun 31 Dec
    1  # No. of periods in day
   0    1   0.000  # ctl type, law (basic control), start @
     7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
* Control function
# senses the temperature of the current zone.
   0    0    0    0  # sensor data
# actuates air point of the current zone
   0    0    0  # actuator data
   1 # No. day types
   1  365  # valid Sun  1 Jan - Sun 31 Dec
    1  # No. of periods in day
   0    1   0.000  # ctl type, law (basic control), start @
     7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
* Control function
  0    1   0.000  # ctl type, law (basic control), start @
     7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
* Control function
# senses the temperature of the current zone.
   0    0    0    0  # sensor data
```

```
# actuates air point of the current zone
    0    0    0  # actuator data
    1 # No. day types
    1  365  # valid Sun  1 Jan - Sun 31 Dec
     1  # No. of periods in day
    0    1   0.000  # ctl type, law (basic control), start @
      7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
* Control function
# senses the temperature of the current zone.
    0    0    0    0  # sensor data
# actuates air point of the current zone
    0    0    0  # actuator data
    0 # No. day types
    1  365  # valid Sun  1 Jan - Sun 31 Dec
     3  # No. of periods in day
    0    2   0.000  # ctl type, law (free floating), start @
      0.  # No. of data items
    0    1   8.000  # ctl type, law (basic control), start @
      7.  # No. of data items
  65000.000 0.000 0.000 0.000 15.000 100.000 0.000
    0    2  17.000  # ctl type, law (free floating), start @
      0.  # No. of data items
    1  365  # valid Sun  1 Jan - Sun 31 Dec
     1  # No. of periods in day
    0    1   0.000  # ctl type, law (basic control), start @
      7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
    1  365  # valid Sun  1 Jan - Sun 31 Dec
     1  # No. of periods in day
    0    1   0.000  # ctl type, law (basic control), start @
      7.  # No. of data items
  65000.000 0.000 0.000 0.000 10.000 100.000 0.000
# Function:Zone links
   3  3  1  1  1  1  1  1  1  1  0  0  0  2  2  3  0
```

9.1.3 Geometry files (.geo)

```
# geometry of Unit_a defined in: ../zones/geo/Unit_a.geo
GEN  Unit_a              # type   zone name
      28      13   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
     12.00000    48.00000     3.80000  # vert  1
     16.00000    48.00000     3.80000  # vert  2
     29.50000    48.00000     3.80000  # vert  3
     29.50000    50.50000     3.80000  # vert  4
     34.00000    50.50000     3.80000  # vert  5
     34.00000    60.00000     3.80000  # vert  6
      9.99900    60.00000     3.80000  # vert  7
     12.00000    48.00000     6.50000  # vert  8
     16.00000    48.00000     6.50000  # vert  9
     29.50000    48.00000     6.50000  # vert 10
     29.50000    50.50000     6.50000  # vert 11
     34.00000    50.50000     6.50000  # vert 12
     34.00000    60.00000     6.50000  # vert 13
     10.00000    60.00000     6.50000  # vert 14
     10.00000    48.00000     3.80000  # vert 15
     10.00000    48.00000     6.50000  # vert 16
     34.00000    51.00000     5.00000  # vert 17
     34.00000    59.00000     5.00000  # vert 18
     34.00000    59.00000     5.90000  # vert 19
     34.00000    51.00000     5.90000  # vert 20
     33.50000    60.00000     5.00000  # vert 21
     10.50000    60.00000     5.00000  # vert 22
     10.50000    60.00000     5.90000  # vert 23
     33.50000    60.00000     5.90000  # vert 24
     10.00000    59.50000     4.53000  # vert 25
     10.00000    48.50000     4.53000  # vert 26
     10.00000    48.50000     6.03000  # vert 27
     10.00000    59.50000     6.03000  # vert 28
# no of vertices followed by list of associated vert
  4,  1,  2,  9,  8,
   4,  2,  3, 10,  9,
   4,  3,  4, 11, 10,
   4,  4,  5, 12, 11,
  10,  5,  6, 13, 12,  5, 17, 20, 19, 18, 17,
  10,  6,  7, 14, 13,  6, 21, 24, 23, 22, 21,
  10,  7, 15, 16, 14,  7, 25, 28, 27, 26, 25,
   8, 16,  8,  9, 10, 11, 12, 13, 14,
   8,  1, 15,  7,  6,  5,  4,  3,  2,
   4, 15,  1,  8, 16,
   4, 17, 18, 19, 20,
   4, 21, 22, 23, 24,
   4, 25, 26, 27, 28,
```

```
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, prt_t        OPAQ  VERT  gyp_blk_ptn  toilets
  2, prt_a-b      OPAQ  VERT  gyp_blk_ptn  Unit_b
  3, str_3        OPAQ  VERT  gyp_blk_ptn  stair_abfg
  4, str_4        OPAQ  VERT  gyp_blk_ptn  stair_abfg
  5, east         OPAQ  VERT  insul_mtl_p  EXTERIOR
  6, north        OPAQ  VERT  insul_mtl_p  EXTERIOR
  7, west         OPAQ  VERT  insul_mtl_p  EXTERIOR
  8, ceil_a       OPAQ  CEIL  susp_ceil    roof
  9, floor        OPAQ  FLOR  susp_floor   ceil_fg
 10, door         OPAQ  VERT  door         corid_1
 11, glz_e        TRAN  VERT  dbl_glz      EXTERIOR
 12, glz_n        TRAN  VERT  dbl_glz      EXTERIOR
 13, glz_w        TRAN  VERT  dbl_glz      EXTERIOR


# geometry of Unit_b defined in: ../zones/geo/Unit_b.geo
GEN  Unit_b                # type   zone name
      16       9   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
     16.00000    36.00000     3.80000  # vert  1
     34.00000    36.00000     3.80000  # vert  2
     34.00000    45.50000     3.80000  # vert  3
     29.50000    45.50000     3.80000  # vert  4
     29.50000    48.00000     3.80000  # vert  5
     16.00000    48.00000     3.80000  # vert  6
     16.00000    36.00000     6.50000  # vert  7
     34.00000    36.00000     6.50000  # vert  8
     34.00000    45.50000     6.50000  # vert  9
     29.50000    45.50000     6.50000  # vert 10
     29.50000    48.00000     6.50000  # vert 11
     16.00000    48.00000     6.50000  # vert 12
     34.00000    36.50000     5.00000  # vert 13
     34.00000    44.50000     5.00000  # vert 14
     34.00000    44.50000     5.90000  # vert 15
     34.00000    36.50000     5.90000  # vert 16
# no of vertices followed by list of associated vert
   4,  1,  2,  8,  7,
  10,  2,  3,  9,  8,  2, 13, 16, 15, 14, 13,
   4,  3,  4, 10,  9,
   4,  4,  5, 11, 10,
   4,  5,  6, 12, 11,
```

```
   4,  6,  1,  7, 12,
   6,  7,  8,  9, 10, 11, 12,
   6,  1,  6,  5,  4,  3,  2,
   4, 13, 14, 15, 16,
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, prt_b-c       OPAQ  VERT  gyp_blk_ptn  Unit_cd
  2, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  3, str_4         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  4, str_5         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  5, prt_a-b       OPAQ  VERT  gyp_blk_ptn  Unit_a
  6, prt_t_b       OPAQ  VERT  gyp_blk_ptn  toilets
  7, ceil_b        OPAQ  CEIL  susp_ceil    roof
  8, floor         OPAQ  FLOR  susp_floor   ceil_fg
  9, glz_e         TRAN  VERT  dbl_glz      EXTERIOR
```

```
# geometry of Unit_cd defined in: ../zones/geo/Unit_cd.geo
GEN  Unit_cd               # type   zone name
      26      13   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
     12.00000    12.00000     3.80000  # vert  1
     29.00000    12.00000     3.80000  # vert  2
     29.00000    14.50000     3.80000  # vert  3
     34.00000    14.50000     3.80000  # vert  4
     34.00000    36.00000     3.80000  # vert  5
     16.00000    36.00000     3.80000  # vert  6
     12.00000    36.00000     3.80000  # vert  7
     12.00000    12.00000     6.50000  # vert  8
     29.00000    12.00000     6.50000  # vert  9
     29.00000    14.50000     6.50000  # vert 10
     34.00000    14.50000     6.50000  # vert 11
     34.00000    36.00000     6.50000  # vert 12
     16.00000    36.00000     6.50000  # vert 13
     12.00000    36.00000     6.50000  # vert 14
     12.00000    28.00000     3.80000  # vert 15
     12.00000    20.00000     3.80000  # vert 16
     12.00000    20.00000     5.90000  # vert 17
     12.00000    28.00000     5.90000  # vert 18
     34.00000    15.50000     5.00000  # vert 19
     34.00000    30.50000     5.00000  # vert 20
     34.00000    30.50000     5.90000  # vert 21
     34.00000    15.50000     5.90000  # vert 22
```

```
    12.20000    24.00000     3.90000  # vert 23
    33.80000    24.00000     3.90000  # vert 24
    33.80000    24.00000     6.40000  # vert 25
    12.10000    24.00000     6.40000  # vert 26
# no of vertices followed by list of associated vert
   8,  7, 15, 18, 17, 16,  1,  8, 14,
   4,  1,  2,  9,  8,
   4,  2,  3, 10,  9,
   4,  3,  4, 11, 10,
  10,  4,  5, 12, 11,  4, 19, 22, 21, 20, 19,
   4,  5,  6, 13, 12,
   4,  6,  7, 14, 13,
   7,  8,  9, 10, 11, 12, 13, 14,
   9,  7,  6,  5,  4,  3,  2,  1, 16, 15,
   4, 15, 16, 17, 18,
   4, 19, 20, 21, 22,
   4, 23, 24, 25, 26,
   4, 24, 23, 26, 25,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name          type  posn  name         other side
  1, passg         OPAQ  VERT  mass_part    corid_1
  2, prt_de        OPAQ  VERT  gyp_blk_ptn  Unit_e
  3, str_2         OPAQ  VERT  gyp_blk_ptn  stair_deij
  4, str_3         OPAQ  VERT  gyp_blk_ptn  stair_deij
  5, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  6, prt_bc        OPAQ  VERT  gyp_blk_ptn  Unit_b
  7, prt_tc        OPAQ  VERT  gyp_blk_ptn  toilets
  8, ceil          OPAQ  CEIL  susp_ceil    roof
  9, floor         OPAQ  FLOR  susp_floor   ceil_chi
 10, door          TRAN  VERT  dbl_glz      corid_1
 11, w_glaz        TRAN  VERT  dbl_glz      EXTERIOR
 12, inner_p1      OPAQ  VERT  mass_part    ADIABATIC
 13, inner_p2      OPAQ  VERT  mass_part    ADIABATIC


# geometry of Unit_e defined in: ../zones/geo/Unit_e.geo
GEN  Unit_e                  # type   zone name
      26       12   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    10.00000     0.00000     3.80000  # vert  1
    34.00000     0.00000     3.80000  # vert  2
    34.00000     9.50000     3.80000  # vert  3
    29.00000     9.50000     3.80000  # vert  4
```

```
    29.00000    12.00000     3.80000  # vert  5
    12.00000    12.00000     3.80000  # vert  6
    10.00000    12.00000     3.80000  # vert  7
    10.00000     0.00000     6.50000  # vert  8
    34.00000     0.00000     6.50000  # vert  9
    34.00000     9.50000     6.50000  # vert 10
    29.00000     9.50000     6.50000  # vert 11
    29.00000    12.00000     6.50000  # vert 12
    12.00000    12.00000     6.50000  # vert 13
    10.00000    12.00000     6.50000  # vert 14
    34.00000     0.50000     5.00000  # vert 15
    34.00000     8.50000     5.00000  # vert 16
    34.00000     8.50000     5.90000  # vert 17
    34.00000     0.50000     5.90000  # vert 18
    10.50000     0.00000     5.00000  # vert 19
    33.50000     0.00000     5.00000  # vert 20
    33.50000     0.00000     5.90000  # vert 21
    10.50000     0.00000     5.90000  # vert 22
    10.00000    11.50000     4.53000  # vert 23
    10.00000     0.50000     4.53000  # vert 24
    10.00000     0.50000     6.03000  # vert 25
    10.00000    11.50000     6.03000  # vert 26
# no of vertices followed by list of associated vert
  10,  1,  2,  9,  8,  1, 19, 22, 21, 20, 19,
  10,  2,  3, 10,  9,  2, 15, 18, 17, 16, 15,
   4,  3,  4, 11, 10,
   4,  4,  5, 12, 11,
   4,  5,  6, 13, 12,
   4,  6,  7, 14, 13,
  10,  7,  1,  8, 14,  7, 23, 26, 25, 24, 23,
   7,  8,  9, 10, 11, 12, 13, 14,
   7,  1,  7,  6,  5,  4,  3,  2,
   4, 15, 16, 17, 18,
   4, 19, 20, 21, 22,
   4, 23, 24, 25, 26,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, south         OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  3, str_3         OPAQ  VERT  gyp_blk_ptn  stair_deij
  4, str_4         OPAQ  VERT  gyp_blk_ptn  stair_deij
  5, prt_d-e       OPAQ  VERT  gyp_blk_ptn  Unit_cd
  6, door          OPAQ  VERT  door         corid_1
  7, west          OPAQ  VERT  insul_mtl_p  EXTERIOR
```

```
  8, ceil_e        OPAQ  CEIL  susp_ceil    roof
  9, floor         OPAQ  FLOR  susp_floor   ceil_j
 10, glz_e         TRAN  VERT  dbl_glz      EXTERIOR
 11, glz_s         TRAN  VERT  dbl_glz      EXTERIOR
 12, glz_w         TRAN  VERT  dbl_glz      EXTERIOR
```

```
# geometry of Unit_f defined in: ../zones/geo/Unit_f.geo
GEN  Unit_f              # type   zone name
    28      13   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    12.00000    48.00000     0.00000  # vert  1
    16.00000    48.00000     0.00000  # vert  2
    29.50000    48.00000     0.00000  # vert  3
    29.50000    50.50000     0.00000  # vert  4
    34.00000    50.50000     0.00000  # vert  5
    34.00000    60.00000     0.00000  # vert  6
    10.00000    60.00000     0.00000  # vert  7
    12.00000    48.00000     2.70000  # vert  8
    16.00000    48.00000     2.70000  # vert  9
    29.50000    48.00000     2.70000  # vert 10
    29.50000    50.50000     2.70000  # vert 11
    34.00000    50.50000     2.70000  # vert 12
    34.00000    60.00000     2.70000  # vert 13
    10.00000    60.00000     2.70000  # vert 14
    10.00000    48.00000     0.00000  # vert 15
    10.00000    48.00000     2.70000  # vert 16
    34.00000    51.00000     1.20000  # vert 17
    34.00000    59.00000     1.20000  # vert 18
    34.00000    59.00000     2.10000  # vert 19
    34.00000    51.00000     2.10000  # vert 20
    33.50000    60.00000     1.20000  # vert 21
    10.50000    60.00000     1.20000  # vert 22
    10.50000    60.00000     2.10000  # vert 23
    33.50000    60.00000     2.10000  # vert 24
    10.00000    59.50000     0.73000  # vert 25
    10.00000    48.50000     0.73000  # vert 26
    10.00000    48.50000     2.23000  # vert 27
    10.00000    59.50000     2.23000  # vert 28
# no of vertices followed by list of associated vert
   4,  1,  2,  9,  8,
   4,  2,  3, 10,  9,
   4,  3,  4, 11, 10,
   4,  4,  5, 12, 11,
  10,  5,  6, 13, 12,  5, 17, 20, 19, 18, 17,
  10,  6,  7, 14, 13,  6, 21, 24, 23, 22, 21,
  10,  7, 15, 16, 14,  7, 25, 28, 27, 26, 25,
   8, 16,  8,  9, 10, 11, 12, 13, 14,
   8,  1, 15,  7,  6,  5,  4,  3,  2,
```

```
   4, 15,  1,  8, 16,
   4, 17, 18, 19, 20,
   4, 21, 22, 23, 24,
   4, 25, 26, 27, 28,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, prt_f-t       OPAQ  VERT  gyp_blk_ptn  toilets
  2, prt_f-g       OPAQ  VERT  gyp_blk_ptn  Unit_g
  3, str_3         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  4, str_4         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  5, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  6, north         OPAQ  VERT  insul_mtl_p  EXTERIOR
  7, west          OPAQ  VERT  insul_mtl_p  EXTERIOR
  8, ceil_f        OPAQ  CEIL  susp_ceil    ceil_fg
  9, floor         OPAQ  FLOR  grnd_floor   GROUND
 10, door          OPAQ  VERT  door         corid_g
 11, glz_e         TRAN  VERT  dbl_glz      EXTERIOR
 12, glz_n         TRAN  VERT  dbl_glz      EXTERIOR
 13, glz_w         TRAN  VERT  dbl_glz      EXTERIOR
```

```
# geometry of Unit_g defined in: ../zones/geo/Unit_g.geo
GEN  Unit_g                # type   zone name
      16       9   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
     16.00000    36.00000     0.00000  # vert  1
     34.00000    36.00000     0.00000  # vert  2
     34.00000    45.50000     0.00000  # vert  3
     29.50000    45.50000     0.00000  # vert  4
     29.50000    48.00000     0.00000  # vert  5
     16.00000    48.00000     0.00000  # vert  6
     16.00000    36.00000     2.70000  # vert  7
     34.00000    36.00000     2.70000  # vert  8
     34.00000    45.50000     2.70000  # vert  9
     29.50000    45.50000     2.70000  # vert 10
     29.50000    48.00000     2.70000  # vert 11
     16.00000    48.00000     2.70000  # vert 12
     34.00000    36.50000     1.20000  # vert 13
     34.00000    44.50000     1.20000  # vert 14
     34.00000    44.50000     2.10000  # vert 15
     34.00000    36.50000     2.10000  # vert 16
# no of vertices followed by list of associated vert
   4,  1,  2,  8,  7,
```

```
 10,  2,  3,  9,  8,  2, 13, 16, 15, 14, 13,
  4,  3,  4, 10,  9,
  4,  4,  5, 11, 10,
  4,  5,  6, 12, 11,
  4,  6,  1,  7, 12,
  6,  7,  8,  9, 10, 11, 12,
  6,  1,  6,  5,  4,  3,  2,
  4, 13, 14, 15, 16,
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
   3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, prt_g-h       OPAQ  VERT  gyp_blk_ptn  Unit_hi
  2, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  3, str_4         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  4, str_5         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  5, prt_f-g       OPAQ  VERT  gyp_blk_ptn  Unit_f
  6, prt_t         OPAQ  VERT  gyp_blk_ptn  toilets
  7, ceil          OPAQ  CEIL  susp_ceil    ceil_fg
  8, floor         OPAQ  FLOR  grnd_floor   GROUND
  9, glz_e         TRAN  VERT  dbl_glz      EXTERIOR


# geometry of Unit_hi defined in: ../zones/geo/Unit_hi.geo
GEN  Unit_hi                # type   zone name
    26      13   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    12.00000    12.00000     0.00000  # vert  1
    29.00000    12.00000     0.00000  # vert  2
    29.00000    14.50000     0.00000  # vert  3
    34.00000    14.50000     0.00000  # vert  4
    34.00000    36.00000     0.00000  # vert  5
    16.00000    36.00000     0.00000  # vert  6
    12.00000    36.00000     0.00000  # vert  7
    12.00000    12.00000     2.70000  # vert  8
    29.00000    12.00000     2.70000  # vert  9
    29.00000    14.50000     2.70000  # vert 10
    34.00000    14.50000     2.70000  # vert 11
    34.00000    36.00000     2.70000  # vert 12
    16.00000    36.00000     2.70000  # vert 13
    12.00000    36.00000     2.70000  # vert 14
    12.00000    28.00000     0.00000  # vert 15
    12.00000    20.00000     0.00000  # vert 16
    12.00000    20.00000     2.10000  # vert 17
    12.00000    28.00000     2.10000  # vert 18
```

```
    34.00000    15.50000     1.20000  # vert 19
    34.00000    30.50000     1.20000  # vert 20
    34.00000    30.50000     2.10000  # vert 21
    34.00000    15.50000     2.10000  # vert 22
    12.20000    24.00000     0.10000  # vert 23
    33.80000    24.00000     0.10000  # vert 24
    33.80000    24.00000     2.60000  # vert 25
    12.10000    24.00000     2.60000  # vert 26
# no of vertices followed by list of associated vert
   8,  7, 15, 18, 17, 16,  1,  8, 14,
   4,  1,  2,  9,  8,
   4,  2,  3, 10,  9,
   4,  3,  4, 11, 10,
  10,  4,  5, 12, 11,  4, 19, 22, 21, 20, 19,
   4,  5,  6, 13, 12,
   4,  6,  7, 14, 13,
   7,  8,  9, 10, 11, 12, 13, 14,
   9,  7,  6,  5,  4,  3,  2,  1, 16, 15,
   4, 15, 16, 17, 18,
   4, 19, 20, 21, 22,
   4, 23, 24, 25, 26,
   4, 24, 23, 26, 25,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, passg        OPAQ  VERT  mass_part    corid_g
  2, prt_ij       OPAQ  VERT  gyp_blk_ptn  Unit_j
  3, str_2        OPAQ  VERT  gyp_blk_ptn  stair_deij
  4, str_3        OPAQ  VERT  gyp_blk_ptn  stair_deij
  5, east         OPAQ  VERT  insul_mtl_p  EXTERIOR
  6, prt_gh       OPAQ  VERT  gyp_blk_ptn  Unit_g
  7, prt_th       OPAQ  VERT  gyp_blk_ptn  toilets
  8, ceil         OPAQ  CEIL  susp_ceil    ceil_chi
  9, floor        OPAQ  FLOR  grnd_floor   GROUND
 10, door         TRAN  VERT  dbl_glz      corid_g
 11, w_glaz       TRAN  VERT  dbl_glz      EXTERIOR
 12, inner_p1     OPAQ  VERT  mass_part    ADIABATIC
 13, inner_p2     OPAQ  VERT  mass_part    ADIABATIC
```

```
# geometry of Unit_j defined in: ../zones/geo/Unit_j.geo
GEN  Unit_j               # type   zone name
      26      12   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
```

```
    10.00000     0.00000     0.00000  # vert  1
    34.00000     0.00000     0.00000  # vert  2
    34.00000     9.50000     0.00000  # vert  3
    29.00000     9.50000     0.00000  # vert  4
    29.00000    12.00000     0.00000  # vert  5
    12.00000    12.00000     0.00000  # vert  6
    10.00000    12.00000     0.00000  # vert  7
    10.00000     0.00000     2.70000  # vert  8
    34.00000     0.00000     2.70000  # vert  9
    34.00000     9.50000     2.70000  # vert 10
    29.00000     9.50000     2.70000  # vert 11
    29.00000    12.00000     2.70000  # vert 12
    12.00000    12.00000     2.70000  # vert 13
    10.00000    12.00000     2.70000  # vert 14
    34.00000     0.50000     1.20000  # vert 15
    34.00000     9.00000     1.20000  # vert 16
    34.00000     9.00000     2.10000  # vert 17
    34.00000     0.50000     2.10000  # vert 18
    10.50000     0.00000     1.20000  # vert 19
    33.50000     0.00000     1.20000  # vert 20
    33.50000     0.00000     2.10000  # vert 21
    10.50000     0.00000     2.10000  # vert 22
    10.00000    11.50000     0.73000  # vert 23
    10.00000     0.50000     0.73000  # vert 24
    10.00000     0.50000     2.23000  # vert 25
    10.00000    11.50000     2.23000  # vert 26
# no of vertices followed by list of associated vert
  10,  1,  2,  9,  8,  1, 19, 22, 21, 20, 19,
  10,  2,  3, 10,  9,  2, 15, 18, 17, 16, 15,
   4,  3,  4, 11, 10,
   4,  4,  5, 12, 11,
   4,  5,  6, 13, 12,
   4,  6,  7, 14, 13,
  10,  7,  1,  8, 14,  7, 23, 26, 25, 24, 23,
   7,  8,  9, 10, 11, 12, 13, 14,
   7,  1,  7,  6,  5,  4,  3,  2,
   4, 15, 16, 17, 18,
   4, 19, 20, 21, 22,
   4, 23, 24, 25, 26,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, south        OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, east         OPAQ  VERT  insul_mtl_p  EXTERIOR
  3, str_3        OPAQ  VERT  gyp_blk_ptn  stair_deij
```

```
# geometry of ceil_chi defined in: ../zones/geo/ceil_chi.geo
GEN  ceil_chi             # type   zone name
    28      18   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    10.00000    48.00000     2.70000  # vert  1
    10.00000    46.00000     2.70000  # vert  2
     7.28300    42.13900     2.70000  # vert  3
    10.00000    38.00000     2.70000  # vert  4
    10.00000    36.00000     2.70000  # vert  5
    10.00000    12.00000     2.70000  # vert  6
    12.00000    12.00000     2.70000  # vert  7
    29.00000    12.00000     2.70000  # vert  8
    29.00000    14.50000     2.70000  # vert  9
    34.00000    14.50000     2.70000  # vert 10
    34.00000    36.00000     2.70000  # vert 11
    16.00000    36.00000     2.70000  # vert 12
    12.00000    36.00000     2.70000  # vert 13
    12.00000    48.00000     2.70000  # vert 14
    10.00000    48.00000     3.80000  # vert 15
    10.00000    46.00000     3.80000  # vert 16
     7.28300    42.13900     3.80000  # vert 17
    10.00000    38.00000     3.80000  # vert 18
    10.00000    36.00000     3.80000  # vert 19
    10.00000    12.00000     3.80000  # vert 20
    12.00000    12.00000     3.80000  # vert 21
    29.00000    12.00000     3.80000  # vert 22
    29.00000    14.50000     3.80000  # vert 23
    34.00000    14.50000     3.80000  # vert 24
    34.00000    36.00000     3.80000  # vert 25
    16.00000    36.00000     3.80000  # vert 26
    12.00000    36.00000     3.80000  # vert 27
    12.00000    48.00000     3.80000  # vert 28
# no of vertices followed by list of associated vert
   4,  1,  2, 16, 15,
   4,  2,  3, 17, 16,
   4,  3,  4, 18, 17,
   4,  4,  5, 19, 18,
   4,  5,  6, 20, 19,
   4,  6,  7, 21, 20,
   4,  7,  8, 22, 21,
   4,  8,  9, 23, 22,
   4,  9, 10, 24, 23,
   4, 10, 11, 25, 24,
   4, 11, 12, 26, 25,
   4, 12, 13, 27, 26,
   4, 13, 14, 28, 27,
   4, 14,  1, 15, 28,
```

```
   7, 21, 22, 23, 24, 25, 26, 27,
   7, 13, 12, 11, 10,  9,  8,  7,
   9,  6,  5,  4,  3,  2,  1, 14, 13,  7,
   9, 15, 16, 17, 18, 19, 20, 21, 27, 28,
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, nw_ext        OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, ent_a         TRAN  VERT  dbl_glz      EXTERIOR
  3, ent_b         TRAN  VERT  dbl_glz      EXTERIOR
  4, ent_c         TRAN  VERT  dbl_glz      EXTERIOR
  5, west          OPAQ  VERT  insul_mtl_p  EXTERIOR
  6, cor_j         OPAQ  VERT  gyp_blk_ptn  ceil_j
  7, prt_ij        OPAQ  VERT  gyp_blk_ptn  ceil_j
  8, str_2         OPAQ  VERT  gyp_blk_ptn  stair_deij
  9, str_3         OPAQ  VERT  gyp_blk_ptn  stair_deij
 10, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
 11, prt_gh        OPAQ  VERT  gyp_blk_ptn  ceil_fg
 12, prt_th        OPAQ  VERT  gyp_blk_ptn  toilets
 13, prt_tcor      OPAQ  VERT  gyp_blk_ptn  toilets
 14, prt_fcor      OPAQ  VERT  gyp_blk_ptn  ceil_fg
 15, upper         OPAQ  CEIL  susp_flr_re  Unit_cd
 16, ceil          OPAQ  FLOR  susp_ceil    Unit_hi
 17, cor_ceil      OPAQ  FLOR  susp_ceil    corid_g
 18, up_cor        OPAQ  CEIL  susp_flr_re  corid_1
```

```
# geometry of ceil_fg defined in: ../zones/geo/ceil_fg.geo
GEN  ceil_fg               # type   zone name
     24      16   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    16.00000    36.00000     2.70000  # vert  1
    34.00000    36.00000     2.70000  # vert  2
    34.00000    45.50000     2.70000  # vert  3
    29.50000    45.50000     2.70000  # vert  4
    29.50000    48.00000     2.70000  # vert  5
    29.50000    50.50000     2.70000  # vert  6
    34.00000    50.50000     2.70000  # vert  7
    34.00000    60.00000     2.70000  # vert  8
    10.00000    60.00000     2.70000  # vert  9
    10.00000    48.00000     2.70000  # vert 10
    12.00000    48.00000     2.70000  # vert 11
    16.00000    48.00000     2.70000  # vert 12
```

```
    16.00000    36.00000     3.80000  # vert 13
    34.00000    36.00000     3.80000  # vert 14
    34.00000    45.50000     3.80000  # vert 15
    29.50000    45.50000     3.80000  # vert 16
    29.50000    48.00000     3.80000  # vert 17
    29.50000    50.50000     3.80000  # vert 18
    34.00000    50.50000     3.80000  # vert 19
    34.00000    60.00000     3.80000  # vert 20
    10.00000    60.00000     3.80000  # vert 21
    10.00000    48.00000     3.80000  # vert 22
    12.00000    48.00000     3.80000  # vert 23
    16.00000    48.00000     3.80000  # vert 24
# no of vertices followed by list of associated vert
   4,  1,  2, 14, 13,
   4,  2,  3, 15, 14,
   4,  3,  4, 16, 15,
   4,  4,  5, 17, 16,
   4,  5,  6, 18, 17,
   4,  6,  7, 19, 18,
   4,  7,  8, 20, 19,
   4,  8,  9, 21, 20,
   4,  9, 10, 22, 21,
   4, 10, 11, 23, 22,
   4, 11, 12, 24, 23,
   4, 12,  1, 13, 24,
   6, 13, 14, 15, 16, 17, 24,
   6,  1, 12,  5,  4,  3,  2,
   8, 21, 22, 23, 24, 17, 18, 19, 20,
   8, 10,  9,  8,  7,  6,  5, 12, 11,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, prt_g-h       OPAQ  VERT  gyp_blk_ptn  ceil_chi
  2, east_s        OPAQ  VERT  insul_mtl_p  EXTERIOR
  3, str_4         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  4, str_5         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  5, str_6         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  6, str_7         OPAQ  VERT  gyp_blk_ptn  stair_abfg
  7, east_n        OPAQ  VERT  insul_mtl_p  EXTERIOR
  8, north         OPAQ  VERT  insul_mtl_p  EXTERIOR
  9, west          OPAQ  VERT  insul_mtl_p  EXTERIOR
 10, cor_d         OPAQ  VERT  gyp_blk_ptn  ceil_chi
 11, prt_t1        OPAQ  VERT  gyp_blk_ptn  toilets
 12, prt_t2        OPAQ  VERT  gyp_blk_ptn  toilets
```

```
 13, floor_b      OPAQ  CEIL  susp_flr_re  Unit_b
 14, ceil_g       OPAQ  FLOR  susp_ceil    Unit_g
 15, floor_a      OPAQ  CEIL  susp_flr_re  Unit_a
 16, ceil_f       OPAQ  FLOR  susp_ceil    Unit_f
```

```
# geometry of ceil_j defined in: ../zones/geo/ceil_j.geo
GEN  ceil_j              # type   zone name
    14       9   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    10.00000     0.00000     2.70000  # vert  1
    34.00000     0.00000     2.70000  # vert  2
    34.00000     9.50000     2.70000  # vert  3
    29.00000     9.50000     2.70000  # vert  4
    29.00000    12.00000     2.70000  # vert  5
    12.00000    12.00000     2.70000  # vert  6
     9.99900    12.00000     2.70000  # vert  7
    10.00000     0.00000     3.80000  # vert  8
    34.00000     0.00000     3.80000  # vert  9
    34.00000     9.50000     3.80000  # vert 10
    29.00000     9.50000     3.80000  # vert 11
    29.00000    12.00000     3.80000  # vert 12
    12.00000    12.00000     3.80000  # vert 13
    10.00000    12.00000     3.80000  # vert 14
# no of vertices followed by list of associated vert
  4,  1,  2,  9,  8,
  4,  2,  3, 10,  9,
  4,  3,  4, 11, 10,
  4,  4,  5, 12, 11,
  4,  5,  6, 13, 12,
  4,  6,  7, 14, 13,
  4,  7,  1,  8, 14,
  7,  8,  9, 10, 11, 12, 13, 14,
  7,  1,  7,  6,  5,  4,  3,  2,
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
   3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, south        OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, east         OPAQ  VERT  insul_mtl_p  EXTERIOR
  3, str_3        OPAQ  VERT  gyp_blk_ptn  stair_deij
  4, str_4        OPAQ  VERT  gyp_blk_ptn  stair_deij
  5, prt_i-j      OPAQ  VERT  gyp_blk_ptn  ceil_chi
  6, cor_dj       OPAQ  VERT  gyp_blk_ptn  ceil_chi
  7, west         OPAQ  VERT  insul_mtl_p  EXTERIOR
```

```
  8, upper        OPAQ  CEIL  susp_flr_re  Unit_e
  9, lower        OPAQ  FLOR  susp_ceil    Unit_j

# geometry of corid_1 defined in: ../zones/geo/corid_1.geo
GEN  corid_1              # type   zone name
     26      13   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    10.00000    36.00000     3.80000  # vert  1
    10.00000    12.00000     3.80000  # vert  2
    12.00000    12.00000     3.80000  # vert  3
    12.00000    36.00000     3.80000  # vert  4
    12.00000    48.00000     3.80000  # vert  5
    10.00000    48.00000     3.80000  # vert  6
    10.00000    46.00000     3.80000  # vert  7
    10.00000    38.00000     3.80000  # vert  8
    10.00000    36.00000     6.50000  # vert  9
    10.00000    12.00000     6.50000  # vert 10
    12.00000    12.00000     6.50000  # vert 11
    12.00000    36.00000     6.50000  # vert 12
    12.00000    48.00000     6.50000  # vert 13
    10.00000    48.00000     6.50000  # vert 14
    10.00000    46.00000     6.50000  # vert 15
    10.00000    38.00000     6.50000  # vert 16
     7.28300    42.13900     3.80000  # vert 17
     7.28300    42.13900     6.50000  # vert 18
    10.00000    35.50000     4.53000  # vert 19
    10.00000    12.50000     4.53000  # vert 20
    10.00000    12.50000     6.03000  # vert 21
    10.00000    35.50000     6.03000  # vert 22
    12.00000    20.00000     3.80000  # vert 23
    12.00000    28.00000     3.80000  # vert 24
    12.00000    28.00000     5.90000  # vert 25
    12.00000    20.00000     5.90000  # vert 26
# no of vertices followed by list of associated vert
  10,  1,  2, 10,  9,  1, 19, 22, 21, 20, 19,
   4,  2,  3, 11, 10,
   8,  3, 23, 26, 25, 24,  4, 12, 11,
   4,  4,  5, 13, 12,
   4,  5,  6, 14, 13,
   4,  6,  7, 15, 14,
   4,  7, 17, 18, 15,
   4,  8,  1,  9, 16,
   9,  9, 10, 11, 12, 13, 14, 15, 18, 16,
  11,  1,  8, 17,  7,  6,  5,  4, 24, 23,  3,  2,
   4, 17,  8, 16, 18,
   4, 19, 20, 21, 22,
   4, 23, 24, 25, 26,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
```

```
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, west_cor      OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, door          OPAQ  VERT  door         Unit_e
  3, prt_d-cor     OPAQ  VERT  mass_part    Unit_cd
  4, prt_t_cor     OPAQ  VERT  gyp_blk_ptn  toilets
  5, door          OPAQ  VERT  door         Unit_a
  6, ent_a         TRAN  VERT  dbl_glz      EXTERIOR
  7, ent_b         TRAN  VERT  dbl_glz      EXTERIOR
  8, ent_c         TRAN  VERT  dbl_glz      EXTERIOR
  9, ceil          OPAQ  CEIL  susp_ceil    roof
 10, floor         OPAQ  FLOR  susp_floor   ceil_chi
 11, ent_d         TRAN  VERT  dbl_glz      EXTERIOR
 12, glz_w         TRAN  VERT  dbl_glz      EXTERIOR
 13, door_dcor     TRAN  VERT  dbl_glz      Unit_cd
```

```
# geometry of corid_g defined in: ../zones/geo/corid_g.geo
GEN  corid_g              # type   zone name
      26      13   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
     10.00000    36.00000     0.00000  # vert  1
     10.00000    12.00000     0.00000  # vert  2
     12.00000    12.00000     0.00000  # vert  3
     12.00000    36.00000     0.00000  # vert  4
     12.00000    48.00000     0.00000  # vert  5
     10.00000    48.00000     0.00000  # vert  6
     10.00000    46.00000     0.00000  # vert  7
     10.00000    38.00000     0.00000  # vert  8
     10.00000    36.00000     2.70000  # vert  9
     10.00000    12.00000     2.70000  # vert 10
     12.00000    12.00000     2.70000  # vert 11
     12.00000    36.00000     2.70000  # vert 12
     12.00000    48.00000     2.70000  # vert 13
     10.00000    48.00000     2.70000  # vert 14
     10.00000    46.00000     2.70000  # vert 15
     10.00000    38.00000     2.70000  # vert 16
      7.28300    42.13900     0.00000  # vert 17
      7.28300    42.13900     2.70000  # vert 18
     10.00000    35.50000     0.73000  # vert 19
     10.00000    12.50000     0.73000  # vert 20
     10.00000    12.50000     2.23000  # vert 21
     10.00100    35.50000     2.23000  # vert 22
     12.00000    20.00000     0.00000  # vert 23
     12.00000    28.00000     0.00000  # vert 24
     12.00000    28.00000     2.10000  # vert 25
```

```
    12.00000    20.00000     2.10000  # vert 26
# no of vertices followed by list of associated vert
  10,  1,  2, 10,  9,  1, 19, 22, 21, 20, 19,
   4,  2,  3, 11, 10,
   8,  3, 23, 26, 25, 24,  4, 12, 11,
   4,  4,  5, 13, 12,
   4,  5,  6, 14, 13,
   4,  6,  7, 15, 14,
   4,  7, 17, 18, 15,
   4,  8,  1,  9, 16,
   9,  9, 10, 11, 12, 13, 14, 15, 18, 16,
  11,  1,  8, 17,  7,  6,  5,  4, 24, 23,  3,  2,
   4, 17,  8, 16, 18,
   4, 19, 20, 21, 22,
   4, 23, 24, 25, 26,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, west_cor      OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, door          OPAQ  VERT  door         Unit_j
  3, prt_i_cor     OPAQ  VERT  mass_part    Unit_hi
  4, prt_t_cor     OPAQ  VERT  gyp_blk_ptn  toilets
  5, door_f        OPAQ  VERT  door         Unit_f
  6, ent_a         TRAN  VERT  dbl_glz      EXTERIOR
  7, ent_b         TRAN  VERT  dbl_glz      EXTERIOR
  8, ent_c         TRAN  VERT  dbl_glz      EXTERIOR
  9, ceil          OPAQ  CEIL  susp_ceil    ceil_chi
 10, floor         OPAQ  FLOR  entry_floor  GROUND
 11, ent_d         TRAN  VERT  dbl_glz      EXTERIOR
 12, glz_w         TRAN  VERT  dbl_glz      EXTERIOR
 13, door_icor     TRAN  VERT  dbl_glz      Unit_hi
```

```
# geometry of roof defined in: ../zones/geo/roof.geo
GEN  roof                 # type   zone name
     31      16   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    10.00000     0.00000     6.50000  # vert  1
    34.00000     0.00000     6.50000  # vert  2
    34.00000     9.50000     6.50000  # vert  3
    34.00000    14.50000     6.50000  # vert  4
    34.00000    36.00000     6.50000  # vert  5
    34.00000    45.50000     6.50000  # vert  6
    34.00000    50.50000     6.50000  # vert  7
```

```
     34.00000    60.00000     6.50000  # vert  8
     10.00000    60.00000     6.50000  # vert  9
     10.00000    48.00000     6.50000  # vert 10
     10.00000    46.00000     6.50000  # vert 11
     10.00000    38.00000     6.50000  # vert 12
     10.00000    36.00000     6.50000  # vert 13
     10.00000    12.00000     6.50000  # vert 14
     22.00000    12.00000    10.00000  # vert 15
     22.00000    48.00000    10.00000  # vert 16
     12.00000    12.00000     6.50000  # vert 17
     29.00000    12.00000     6.50000  # vert 18
     29.00000     9.50000     6.50000  # vert 19
     29.00000    14.50000     6.50000  # vert 20
     12.00000    36.00000     6.50000  # vert 21
     16.00000    36.00000     6.50000  # vert 22
     29.50000    45.50000     6.50000  # vert 23
     29.50000    48.00000     6.50000  # vert 24
     29.50000    50.50000     6.50000  # vert 25
     16.00000    48.00000     6.50000  # vert 26
     12.00000    48.00000     6.50000  # vert 27
      7.28300    42.13900     6.50000  # vert 28
      7.00000    48.00000     6.50000  # vert 29
      7.00000    36.00000     6.50000  # vert 30
     16.00000    42.00000     9.00000  # vert 31
# no of vertices followed by list of associated vert
   3,  1,  2, 15,
   9,  2,  3,  4,  5,  6,  7,  8, 16, 15,
   3,  8,  9, 16,
   8,  9, 10, 31, 13, 14,  1, 15, 16,
   7, 21, 22,  5,  4, 20, 18, 17,
   7,  1, 14, 17, 18, 19,  3,  2,
   5,  4,  3, 19, 18, 20,
   4, 21, 27, 26, 22,
   8, 10,  9,  8,  7, 25, 24, 26, 27,
   5, 23, 24, 25,  7,  6,
   9, 14, 13, 12, 28, 11, 10, 27, 21, 17,
   7, 30, 29, 10, 11, 28, 12, 13,
   3, 10, 29, 31,
   3, 29, 30, 31,
   3, 30, 13, 31,
   6, 22, 26, 24, 23,  6,  5,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
```

```
 1, south        OPAQ  UNKN  roof        EXTERIOR
 2, east         OPAQ  UNKN  roof        EXTERIOR
 3, north        OPAQ  UNKN  roof        EXTERIOR
 4, west         OPAQ  UNKN  roof        EXTERIOR
 5, ceil_c       OPAQ  FLOR  susp_ceil    Unit_cd
 6, ceil_e       OPAQ  FLOR  susp_ceil    Unit_e
 7, stair_de     OPAQ  FLOR  susp_ceil    stair_deij
 8, ceil_t       OPAQ  FLOR  susp_ceil    toilets
 9, ceil_a       OPAQ  FLOR  susp_ceil    Unit_a
10, stair_ab     OPAQ  FLOR  susp_ceil    stair_abfg
11, corid_c      OPAQ  FLOR  susp_ceil    corid_1
12, sofit        OPAQ  FLOR  insul_mtl_p  EXTERIOR
13, ent_r_n      OPAQ  UNKN  roof        EXTERIOR
14, ent_r_w      OPAQ  UNKN  roof        EXTERIOR
15, ent_r_s      OPAQ  UNKN  roof        EXTERIOR
16, ceil_b       OPAQ  FLOR  susp_ceil    Unit_b
```

```
# geometry of stair_abfg defined in: ../zones/geo/stair_abfg.geo
GEN  stair_abfg            # type   zone name
    24       16   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    34.00000    45.50000     0.00000  # vert  1
    34.00000    50.50000     0.00000  # vert  2
    29.50000    50.50000     0.00000  # vert  3
    29.50000    48.00000     0.00000  # vert  4
    29.50000    45.50000     0.00000  # vert  5
    34.00000    45.50000     6.50000  # vert  6
    34.00000    50.50000     6.50000  # vert  7
    29.50000    50.50000     6.50000  # vert  8
    29.50000    48.00000     6.50000  # vert  9
    29.50000    45.50000     6.50000  # vert 10
    34.00000    45.50000     2.70000  # vert 11
    34.00000    45.50000     3.80000  # vert 12
    34.00000    50.50000     2.70000  # vert 13
    34.00000    50.50000     3.80000  # vert 14
    29.50000    50.50000     2.70000  # vert 15
    29.50000    50.50000     3.80000  # vert 16
    29.50000    48.00000     2.70000  # vert 17
    29.50000    48.00000     3.80000  # vert 18
    29.50000    45.50000     2.70000  # vert 19
    29.50000    45.50000     3.80000  # vert 20
    34.00000    46.50000     0.00000  # vert 21
    34.00000    47.30000     0.00000  # vert 22
    34.00000    47.30000     2.10000  # vert 23
    34.00000    46.50000     2.10000  # vert 24
# no of vertices followed by list of associated vert
  12,  1, 21, 24, 23, 22,  2, 13, 14,  7,  6, 12, 11,
   4,  2,  3, 15, 13,
```

```
  4,  3,  4, 17, 15,
  4,  4,  5, 19, 17,
  4,  5,  1, 11, 19,
  5,  6,  7,  8,  9, 10,
  7,  1,  5,  4,  3,  2, 22, 21,
  4, 19, 11, 12, 20,
  4, 20, 12,  6, 10,
  4, 17, 19, 20, 18,
  4, 18, 20, 10,  9,
  4, 15, 17, 18, 16,
  4, 16, 18,  9,  8,
  4, 13, 15, 16, 14,
  4, 14, 16,  8,  7,
  4, 21, 22, 23, 24,
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, prt_f         OPAQ  VERT  gyp_blk_ptn  Unit_f
  3, prt_f1        OPAQ  VERT  gyp_blk_ptn  Unit_f
  4, prt_g         OPAQ  VERT  gyp_blk_ptn  Unit_g
  5, prt_g1        OPAQ  VERT  gyp_blk_ptn  Unit_g
  6, ceil          OPAQ  CEIL  susp_ceil    roof
  7, floor         OPAQ  FLOR  grnd_floor   GROUND
  8, prt_gc1       OPAQ  VERT  gyp_blk_ptn  ceil_fg
  9, prt_b1        OPAQ  VERT  gyp_blk_ptn  Unit_b
 10, prt_gc        OPAQ  VERT  gyp_blk_ptn  ceil_fg
 11, prt_b         OPAQ  VERT  gyp_blk_ptn  Unit_b
 12, prt_ac1       OPAQ  VERT  gyp_blk_ptn  ceil_fg
 13, prt_a1        OPAQ  VERT  gyp_blk_ptn  Unit_a
 14, prt_ac        OPAQ  VERT  gyp_blk_ptn  ceil_fg
 15, prt_a         OPAQ  VERT  gyp_blk_ptn  Unit_a
 16, door          OPAQ  VERT  door         EXTERIOR
```

```
# geometry of stair_deij defined in: ../zones/geo/stair_deij.geo
GEN  stair_deij             # type   zone name
     24      16   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    34.00000     9.50000     0.00000  # vert  1
    34.00000    14.50000     0.00000  # vert  2
    29.00000    14.50000     0.00000  # vert  3
    29.00000    12.00000     0.00000  # vert  4
```

```
    29.00000     9.50000     0.00000  # vert  5
    34.00000     9.50000     6.50000  # vert  6
    34.00000    14.50000     6.50000  # vert  7
    29.00000    14.50000     6.50000  # vert  8
    29.00000    12.00000     6.50000  # vert  9
    29.00000     9.50000     6.50000  # vert 10
    34.00000     9.50000     2.70000  # vert 11
    34.00000     9.50000     3.80000  # vert 12
    34.00000    14.50000     2.70000  # vert 13
    34.00000    14.50000     3.80000  # vert 14
    29.00000    14.50000     2.70000  # vert 15
    29.00000    14.50000     3.80000  # vert 16
    29.00000    12.00000     2.70000  # vert 17
    29.00000    12.00000     3.80000  # vert 18
    29.00000     9.50000     2.70000  # vert 19
    29.00000     9.50000     3.80000  # vert 20
    34.00000    10.50000     0.00000  # vert 21
    34.00000    11.30000     0.00000  # vert 22
    34.00000    11.30000     2.10000  # vert 23
    34.00000    10.50000     2.10000  # vert 24
# no of vertices followed by list of associated vert
  12,  1, 21, 24, 23, 22,  2, 13, 14,  7,  6, 12, 11,
   4,  2,  3, 15, 13,
   4,  3,  4, 17, 15,
   4,  4,  5, 19, 17,
   4,  5,  1, 11, 19,
   5,  6,  7,  8,  9, 10,
   7,  1,  5,  4,  3,  2, 22, 21,
   4, 19, 11, 12, 20,
   4, 20, 12,  6, 10,
   4, 17, 19, 20, 18,
   4, 18, 20, 10,  9,
   4, 15, 17, 18, 16,
   4, 16, 18,  9,  8,
   4, 13, 15, 16, 14,
   4, 14, 16,  8,  7,
   4, 21, 22, 23, 24,
# number of default windows within each surface
   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
    3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name          type  posn  name         other side
  1, east          OPAQ  VERT  insul_mtl_p  EXTERIOR
  2, prt_i         OPAQ  VERT  gyp_blk_ptn  Unit_hi
  3, prt_i1        OPAQ  VERT  gyp_blk_ptn  Unit_hi
  4, prt_j         OPAQ  VERT  gyp_blk_ptn  Unit_j
```

```
  5, prt_j1       OPAQ  VERT  gyp_blk_ptn  Unit_j
  6, ceil         OPAQ  CEIL  susp_ceil    roof
  7, floor        OPAQ  FLOR  grnd_floor   GROUND
  8, prt_cj1      OPAQ  VERT  gyp_blk_ptn  ceil_j
  9, prt_e1       OPAQ  VERT  gyp_blk_ptn  Unit_e
 10, prt_cj       OPAQ  VERT  gyp_blk_ptn  ceil_j
 11, prt_e        OPAQ  VERT  gyp_blk_ptn  Unit_e
 12, prt_ci1      OPAQ  VERT  gyp_blk_ptn  ceil_chi
 13, prt_d1       OPAQ  VERT  gyp_blk_ptn  Unit_cd
 14, prt_ci       OPAQ  VERT  gyp_blk_ptn  ceil_chi
 15, prt_d        OPAQ  VERT  gyp_blk_ptn  Unit_cd
 16, door         OPAQ  VERT  door         EXTERIOR


# geometry of toilets defined in: ../zones/geo/toilets.geo
GEN  toilets              # type   zone name
    16      14   0.000    # vertices, surfaces, rotation angle
#  X co-ord, Y co-ord, Z co-ord
    12.00000   48.00000    0.00000  # vert  1
    12.00000   36.00000    0.00000  # vert  2
    16.00000   36.00000    0.00000  # vert  3
    16.00000   48.00000    0.00000  # vert  4
    12.00000   48.00000    6.50000  # vert  5
    12.00000   36.00000    6.50000  # vert  6
    16.00000   36.00000    6.50000  # vert  7
    16.00000   48.00000    6.50000  # vert  8
    12.00000   48.00000    2.70000  # vert  9
    12.00000   48.00000    3.80000  # vert 10
    12.00000   36.00000    2.70000  # vert 11
    12.00000   36.00000    3.80000  # vert 12
    16.00000   36.00000    2.70000  # vert 13
    16.00000   36.00000    3.80000  # vert 14
    16.00000   48.00000    2.70000  # vert 15
    16.00000   48.00000    3.80000  # vert 16
# no of vertices followed by list of associated vert
   4,  1,  2, 11,  9,
   4,  2,  3, 13, 11,
   4,  3,  4, 15, 13,
   4,  4,  1,  9, 15,
   4,  5,  6,  7,  8,
   4,  1,  4,  3,  2,
   4,  9, 11, 12, 10,
   4, 10, 12,  6,  5,
   4, 11, 13, 14, 12,
   4, 12, 14,  7,  6,
   4, 13, 15, 16, 14,
   4, 14, 16,  8,  7,
   4, 15,  9, 10, 16,
   4, 16, 10,  5,  8,
```

```
# number of default windows within each surface
  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# surfaces indentation (m)
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000
   3   0   0   0    # default insolation distribution
# surface attributes follow:
# id  surface      geom  loc/  mlc db       environment
# no  name         type  posn  name         other side
  1, prt_tcor      OPAQ  VERT  gyp_blk_ptn  corid_g
  2, prt_th        OPAQ  VERT  gyp_blk_ptn  Unit_hi
  3, prt_tg        OPAQ  VERT  gyp_blk_ptn  Unit_g
  4, prt_ft        OPAQ  VERT  gyp_blk_ptn  Unit_f
  5, ceiling       OPAQ  CEIL  susp_ceil    roof
  6, floor         OPAQ  FLOR  grnd_floor   GROUND
  7, prt_tcorc     OPAQ  VERT  gyp_blk_ptn  ceil_chi
  8, prt_tcor1     OPAQ  VERT  gyp_blk_ptn  corid_1
  9, prt_cth       OPAQ  VERT  gyp_blk_ptn  ceil_chi
 10, prt_ctc       OPAQ  VERT  gyp_blk_ptn  Unit_cd
 11, prt_ctb       OPAQ  VERT  gyp_blk_ptn  ceil_fg
 12, prt_tb        OPAQ  VERT  gyp_blk_ptn  Unit_b
 13, prt_cat       OPAQ  VERT  gyp_blk_ptn  ceil_fg
 14, prt_ta        OPAQ  VERT  gyp_blk_ptn  Unit_a
```

9.1.4 Construction files (.con)

```
# thermophysical properties of Unit_a defined in ../zones/Unit_a.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    5,    2  #  1 prt_t        gyp_blk_ptn
    5,    2  #  2 prt_a-b      gyp_blk_ptn
    5,    2  #  3 str_3        gyp_blk_ptn
    5,    2  #  4 str_4        gyp_blk_ptn
    3,    0  #  5 east         insul_mtl_p
    3,    0  #  6 north        insul_mtl_p
    3,    0  #  7 west         insul_mtl_p
    1,    0  #  8 ceil_a       susp_ceil
    5,    1  #  9 floor        susp_floor
    1,    0  # 10 door         door
    3,    1  # 11 glz_e        dbl_glz
    3,    1  # 12 glz_n        dbl_glz
    3,    1  # 13 glz_w        dbl_glz
# air gap position & resistance for surface  1
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
```

  2,   0.170, 4,   0.170,
air gap position & resistance for surface 9
  3,   0.170,
air gap position & resistance for surface 11
  2,   0.170,
air gap position & resistance for surface 12
  2,   0.170,
air gap position & resistance for surface 13
  2,   0.170,

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor	surf	lyr
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 1	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 2	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 5	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 6	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 7	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 8	1
0.0600,	186.0,	1360.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 9	1
0.1500,	800.0,	2093.0,	0.0190,	0,	0.00,	0.00000,	0.00000	#	2
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	3
1.4000,	2100.0,	653.0,	0.1400,	0,	0.00,	0.00000,	0.00000	#	4
50.0000,	7800.0,	502.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	700.0,	2390.0,	0.0250,	0,	0.00,	0.00000,	0.00000	# 10	1
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 11	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 12	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 13	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3

for each surface: inside face emissivity
  0.91 0.91 0.91 0.91 0.82 0.82 0.82 0.91 0.12 0.90 0.83 0.83 0.83
for each surface: outside face emissivity
  0.91 0.91 0.91 0.91 0.82 0.82 0.82 0.91 0.90 0.90 0.83 0.83 0.83
for each surface: inside face solar absorptivity
  0.22 0.22 0.22 0.22 0.32 0.32 0.32 0.50 0.20 0.65 0.05 0.05 0.05
for each surface: outside face solar absorptivity
  0.22 0.22 0.22 0.22 0.72 0.72 0.72 0.50 0.60 0.65 0.05 0.05 0.05

```
# inside and exterior glazing maintenance factors
  1.00   1.00


# thermophysical properties of Unit_b defined in ../zones/Unit_b.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    5,    2  #  1 prt_b-c      gyp_blk_ptn
    3,    0  #  2 east         insul_mtl_p
    5,    2  #  3 str_4        gyp_blk_ptn
    5,    2  #  4 str_5        gyp_blk_ptn
    5,    2  #  5 prt_a-b      gyp_blk_ptn
    5,    2  #  6 prt_t_b      gyp_blk_ptn
    1,    0  #  7 ceil_b       susp_ceil
    5,    1  #  8 floor        susp_floor
    3,    1  #  9 glz_e        dbl_glz
# air gap position & resistance for surface  1
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  5
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  6
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  8
  3,   0.170,
# air gap position & resistance for surface  9
  2,   0.170,
```

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor		surf	lyr
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	1	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	2	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	6	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	7	1
0.0600,	186.0,	1360.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	8	1
0.1500,	800.0,	2093.0,	0.0190,	0,	0.00,	0.00000,	0.00000	#		2
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		3
1.4000,	2100.0,	653.0,	0.1400,	0,	0.00,	0.00000,	0.00000	#		4
50.0000,	7800.0,	502.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		5
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	9	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#		2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#		3

for each surface: inside face emissivity
0.91 0.82 0.91 0.91 0.91 0.91 0.91 0.12 0.83
for each surface: outside face emissivity
0.91 0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.83
for each surface: inside face solar absorptivity
0.22 0.32 0.22 0.22 0.22 0.22 0.50 0.20 0.05
for each surface: outside face solar absorptivity
0.22 0.72 0.22 0.22 0.22 0.22 0.50 0.60 0.05
inside and exterior glazing maintenance factors
1.00 1.00

thermophysical properties of Unit_cd defined in ../zones/Unit_cd.con
no of |air |surface(from geo)| multilayer construction
layers|gaps| no. name | database name
1, 0 # 1 passg mass_part
5, 2 # 2 prt_de gyp_blk_ptn
5, 2 # 3 str_2 gyp_blk_ptn
5, 2 # 4 str_3 gyp_blk_ptn
3, 0 # 5 east insul_mtl_p

```
    5,     2  #  6 prt_bc       gyp_blk_ptn
    5,     2  #  7 prt_tc       gyp_blk_ptn
    1,     0  #  8 ceil         susp_ceil
    5,     1  #  9 floor        susp_floor
    3,     1  # 10 door         dbl_glz
    3,     1  # 11 w_glaz       dbl_glz
    1,     0  # 12 inner_p1     mass_part
    1,     0  # 13 inner_p2     mass_part
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  6
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  7
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  9
  3,   0.170,
# air gap position & resistance for surface 10
  2,   0.170,
# air gap position & resistance for surface 11
  2,   0.170,
```

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor	surf	lyr
0.5100,	1400.0,	1000.0,	0.2400,	0,	0.00,	0.00000,	0.00000	# 1	1
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 2	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 5	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 6	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 7	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 8	1
0.0600,	186.0,	1360.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 9	1
0.1500,	800.0,	2093.0,	0.0190,	0,	0.00,	0.00000,	0.00000	#	2
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	3
1.4000,	2100.0,	653.0,	0.1400,	0,	0.00,	0.00000,	0.00000	#	4
50.0000,	7800.0,	502.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	5
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 10	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 11	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3
0.5100,	1400.0,	1000.0,	0.2400,	0,	0.00,	0.00000,	0.00000	# 12	1
0.5100,	1400.0,	1000.0,	0.2400,	0,	0.00,	0.00000,	0.00000	# 13	1

for each surface: inside face emissivity
0.90 0.91 0.91 0.91 0.82 0.91 0.91 0.91 0.12 0.83 0.83 0.90 0.90
for each surface: outside face emissivity
0.90 0.91 0.91 0.91 0.82 0.91 0.91 0.91 0.90 0.83 0.83 0.90 0.90
for each surface: inside face solar absorptivity
0.25 0.22 0.22 0.22 0.32 0.22 0.22 0.50 0.20 0.05 0.05 0.25 0.25
for each surface: outside face solar absorptivity
0.25 0.22 0.22 0.22 0.72 0.22 0.22 0.50 0.60 0.05 0.05 0.25 0.25
inside and exterior glazing maintenance factors
1.0 1.00

```
# thermophysical properties of Unit_e defined in ../zones/Unit_e.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name      | database name
    3,     0  #  1 south        insul_mtl_p
    3,     0  #  2 east         insul_mtl_p
    5,     2  #  3 str_3        gyp_blk_ptn
    5,     2  #  4 str_4        gyp_blk_ptn
    5,     2  #  5 prt_d-e      gyp_blk_ptn
    1,     0  #  6 door         door
    3,     0  #  7 west         insul_mtl_p
    1,     0  #  8 ceil_e       susp_ceil
    5,     1  #  9 floor        susp_floor
    3,     1  # 10 glz_e        dbl_glz
    3,     1  # 11 glz_s        dbl_glz
    3,     1  # 12 glz_w        dbl_glz
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  5
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  9
  3,   0.170,
# air gap position & resistance for surface 10
  2,   0.170,
# air gap position & resistance for surface 11
  2,   0.170,
# air gap position & resistance for surface 12
  2,   0.170,
```

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor		surf	lyr
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	1	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	2	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	700.0,	2390.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	6	1
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	7	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	8	1

0.0600,	186.0,	1360.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	9	1
0.1500,	800.0,	2093.0,	0.0190,	0,	0.00,	0.00000,	0.00000	#		2
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		3
1.4000,	2100.0,	653.0,	0.1400,	0,	0.00,	0.00000,	0.00000	#		4
50.0000,	7800.0,	502.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		5
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	10	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#		2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#		3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	11	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#		2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#		3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	12	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#		2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#		3

```
# for each surface: inside face emissivity
  0.82 0.82 0.91 0.91 0.91 0.90 0.82 0.91 0.12 0.83 0.83 0.83
# for each surface: outside face emissivity
  0.82 0.82 0.91 0.91 0.91 0.90 0.82 0.91 0.90 0.83 0.83 0.83
# for each surface: inside face solar absorptivity
  0.32 0.32 0.22 0.22 0.22 0.65 0.32 0.50 0.20 0.05 0.05 0.05
# for each surface: outside face solar absorptivity
  0.72 0.72 0.22 0.22 0.22 0.65 0.72 0.50 0.60 0.05 0.05 0.05
# inside and exterior glazing maintenance factors
   1.0    1.00
```

```
# thermophysical properties of Unit_f defined in ../zones/Unit_f.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name      | database name
     5,     2  #  1 prt_f-t      gyp_blk_ptn
     5,     2  #  2 prt_f-g      gyp_blk_ptn
     5,     2  #  3 str_3        gyp_blk_ptn
     5,     2  #  4 str_4        gyp_blk_ptn
     3,     0  #  5 east         insul_mtl_p
     3,     0  #  6 north        insul_mtl_p
     3,     0  #  7 west         insul_mtl_p
     1,     0  #  8 ceil_f       susp_ceil
     6,     1  #  9 floor        grnd_floor
     1,     0  # 10 door         door
     3,     1  # 11 glz_e        dbl_glz
     3,     1  # 12 glz_n        dbl_glz
     3,     1  # 13 glz_w        dbl_glz
# air gap position & resistance for surface  1
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  9
  4,   0.170,
# air gap position & resistance for surface 11
```

2, 0.170,
air gap position & resistance for surface 12
2, 0.170,
air gap position & resistance for surface 13
2, 0.170,

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor	surf	lyr
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 1	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 2	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 5	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 6	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 7	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 8	1
1.2800,	1460.0,	879.0,	0.2500,	0,	0.00,	0.00000,	0.00000	# 9	1
0.5200,	2050.0,	184.0,	0.1500,	0,	0.00,	0.00000,	0.00000	#	2
1.4000,	2100.0,	653.0,	0.1500,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1500,	800.0,	2093.0,	0.0190,	0,	0.00,	0.00000,	0.00000	#	5
0.0600,	186.0,	1360.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	6
0.1900,	700.0,	2390.0,	0.0250,	0,	0.00,	0.00000,	0.00000	# 10	1
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 11	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 13	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3

for each surface: inside face emissivity
0.91 0.91 0.91 0.91 0.82 0.82 0.82 0.91 0.90 0.90 0.83 0.83 0.83
for each surface: outside face emissivity
0.91 0.91 0.91 0.91 0.82 0.82 0.82 0.91 0.90 0.90 0.83 0.83 0.83
for each surface: inside face solar absorptivity
0.22 0.22 0.22 0.22 0.32 0.32 0.32 0.50 0.60 0.65 0.05 0.05 0.05
for each surface: outside face solar absorptivity
0.22 0.22 0.22 0.22 0.72 0.72 0.72 0.50 0.85 0.65 0.05 0.05 0.05
inside and exterior glazing maintenance factors
1.00 1.00

```
# thermophysical properties of Unit_g defined in ../zones/Unit_g.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    5,    2  #  1 prt_g-h      gyp_blk_ptn
    3,    0  #  2 east         insul_mtl_p
    5,    2  #  3 str_4        gyp_blk_ptn
    5,    2  #  4 str_5        gyp_blk_ptn
    5,    2  #  5 prt_f-g      gyp_blk_ptn
    5,    2  #  6 prt_t        gyp_blk_ptn
    1,    0  #  7 ceil         susp_ceil
    6,    1  #  8 floor        grnd_floor
    3,    1  #  9 glz_e        dbl_glz
# air gap position & resistance for surface  1
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  5
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  6
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  8
  4,   0.170,
# air gap position & resistance for surface  9
  2,   0.170,
```

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor		surf	lyr
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	1	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	2	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	6	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	7	1
1.2800,	1460.0,	879.0,	0.2500,	0,	0.00,	0.00000,	0.00000	#	8	1
0.5200,	2050.0,	184.0,	0.1500,	0,	0.00,	0.00000,	0.00000	#		2
1.4000,	2100.0,	653.0,	0.1500,	0,	0.00,	0.00000,	0.00000	#		3

```
   0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
   0.1500,    800.0,    2093.0,  0.0190,   0,   0.00, 0.00000, 0.00000  #     5
   0.0600,    186.0,    1360.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     6
   0.7600,   2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  9  1
   0.0000,      0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
   0.7600,   2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
# for each surface: inside face emissivity
  0.91 0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.83
# for each surface: outside face emissivity
  0.91 0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.83
# for each surface: inside face solar absorptivity
  0.22 0.32 0.22 0.22 0.22 0.22 0.50 0.60 0.05
# for each surface: outside face solar absorptivity
  0.22 0.72 0.22 0.22 0.22 0.22 0.50 0.85 0.05
# inside and exterior glazing maintenance factors
   1.00   1.00


# thermophysical properties of Unit_hi defined in ../zones/Unit_hi.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name      | database name
     1,    0  #  1 passg        mass_part
     5,    2  #  2 prt_ij       gyp_blk_ptn
     5,    2  #  3 str_2        gyp_blk_ptn
     5,    2  #  4 str_3        gyp_blk_ptn
     3,    0  #  5 east         insul_mtl_p
     5,    2  #  6 prt_gh       gyp_blk_ptn
     5,    2  #  7 prt_th       gyp_blk_ptn
     1,    0  #  8 ceil         susp_ceil
     6,    1  #  9 floor        grnd_floor
     3,    1  # 10 door         dbl_glz
     3,    1  # 11 w_glaz       dbl_glz
     1,    0  # 12 inner_p1     mass_part
     1,    0  # 13 inner_p2     mass_part
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  6
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  7
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  9
  4,   0.170,
# air gap position & resistance for surface 10
  2,   0.170,
# air gap position & resistance for surface 11
  2,   0.170,
```

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor	surf	lyr
0.5100,	1400.0,	1000.0,	0.2400,	0,	0.00,	0.00000,	0.00000	# 1	1
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 2	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 5	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 6	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 7	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 8	1
1.2800,	1460.0,	879.0,	0.2500,	0,	0.00,	0.00000,	0.00000	# 9	1
0.5200,	2050.0,	184.0,	0.1500,	0,	0.00,	0.00000,	0.00000	#	2
1.4000,	2100.0,	653.0,	0.1500,	0,	0.00,	0.00000,	0.00000	#	3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#	4
0.1500,	800.0,	2093.0,	0.0190,	0,	0.00,	0.00000,	0.00000	#	5
0.0600,	186.0,	1360.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	6
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 10	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600.	2710.0.	837.0.	0.0060.	0.	0.00.	0.00000.	0.00000	#	3
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	# 11	1
0.0000,	0.0,	0.0,	0.0120,	0,	0.00,	0.00000,	0.00000	#	2
0.7600,	2710.0,	837.0,	0.0060,	0,	0.00,	0.00000,	0.00000	#	3
0.5100,	1400.0,	1000.0,	0.2400,	0,	0.00,	0.00000,	0.00000	# 12	1
0.5100,	1400.0,	1000.0,	0.2400,	0,	0.00,	0.00000,	0.00000	# 13	1

for each surface: inside face emissivity
0.90 0.91 0.91 0.91 0.82 0.91 0.91 0.91 0.90 0.83 0.83 0.90 0.90
for each surface: outside face emissivity
0.90 0.91 0.91 0.91 0.82 0.91 0.91 0.91 0.90 0.83 0.83 0.90 0.90
for each surface: inside face solar absorptivity
0.25 0.22 0.22 0.22 0.32 0.22 0.22 0.50 0.60 0.05 0.05 0.25 0.25
for each surface: outside face solar absorptivity
0.25 0.22 0.22 0.22 0.72 0.22 0.22 0.50 0.85 0.05 0.05 0.25 0.25
inside and exterior glazing maintenance factors
1.00 1.00

```
# thermophysical properties of Unit_j defined in ../zones/Unit_j.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    3,     0  #  1 south        insul_mtl_p
    3,     0  #  2 east         insul_mtl_p
    5,     2  #  3 str_3        gyp_blk_ptn
    5,     2  #  4 str_4        gyp_blk_ptn
    5,     2  #  5 prt_i-j      gyp_blk_ptn
    1,     0  #  6 door         door
    3,     0  #  7 west         insul_mtl_p
    1,     0  #  8 ceil_j       susp_ceil
    6,     1  #  9 floor        grnd_floor
    3,     1  # 10 glz_e        dbl_glz
    3,     1  # 11 glz_s        dbl_glz
    3,     1  # 12 glz_w        dbl_glz
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  5
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  9
  4,   0.170,
# air gap position & resistance for surface 10
  2,   0.170,
# air gap position & resistance for surface 11
  2,   0.170,
# air gap position & resistance for surface 12
  2,   0.170,
```

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor		surf	lyr
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	1	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	2	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	3	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	4	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	5	1
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		2
0.5100,	1400.0,	1000.0,	0.1000,	0,	0.00,	0.00000,	0.00000	#		3
0.0000,	0.0,	0.0,	0.0500,	0,	0.00,	0.00000,	0.00000	#		4
0.1900,	950.0,	840.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#		5
0.1900,	700.0,	2390.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	6	1
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	7	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#		2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#		3
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	#	8	1
1.2800,	1460.0,	879.0,	0.2500,	0,	0.00,	0.00000,	0.00000	#	9	1

```
    0.5200,    2050.0,     184.0,  0.1500,   0,    0.00, 0.00000, 0.00000  #      2
    1.4000,    2100.0,     653.0,  0.1500,   0,    0.00, 0.00000, 0.00000  #      3
    0.0000,       0.0,       0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #      4
    0.1500,     800.0,    2093.0,  0.0190,   0,    0.00, 0.00000, 0.00000  #      5
    0.0600,     186.0,    1360.0,  0.0060,   0,    0.00, 0.00000, 0.00000  #      6
    0.7600,    2710.0,     837.0,  0.0060,   0,    0.00, 0.00000, 0.00000  # 10   1
    0.0000,       0.0,       0.0,  0.0120,   0,    0.00, 0.00000, 0.00000  #      2
    0.7600,    2710.0,     837.0,  0.0060,   0,    0.00, 0.00000, 0.00000  #      3
    0.7600,    2710.0,     837.0,  0.0060,   0,    0.00, 0.00000, 0.00000  # 11   1
    0.0000,       0.0,       0.0,  0.0120,   0,    0.00, 0.00000, 0.00000  #      2
    0.7600,    2710.0,     837.0,  0.0060,   0,    0.00, 0.00000, 0.00000  #      3
    0.7600,    2710.0,     837.0,  0.0060,   0,    0.00, 0.00000, 0.00000  # 12   1
    0.0000,       0.0,       0.0,  0.0120,   0,    0.00, 0.00000, 0.00000  #      2
    0.7600,    2710.0,     837.0,  0.0060,   0,    0.00, 0.00000, 0.00000  #      3
```

```
# for each surface: inside face emissivity
  0.82 0.82 0.91 0.91 0.91 0.90 0.82 0.91 0.90 0.83 0.83 0.83
# for each surface: outside face emissivity
  0.82 0.82 0.91 0.91 0.91 0.90 0.82 0.91 0.90 0.83 0.83 0.83
# for each surface: inside face solar absorptivity
  0.32 0.32 0.22 0.22 0.22 0.65 0.32 0.50 0.60 0.05 0.05 0.05
# for each surface: outside face solar absorptivity
  0.72 0.72 0.22 0.22 0.22 0.65 0.72 0.50 0.85 0.05 0.05 0.05
# inside and exterior glazing maintenance factors
   1.00   1.00
```

```
# thermophysical properties of ceil_chi defined in ../zones/ceil_chi.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    3,    0  #  1 nw_ext       insul_mtl_p
    3,    1  #  2 ent_a        dbl_glz
    3,    1  #  3 ent_b        dbl_glz
    3,    1  #  4 ent_c        dbl_glz
    3,    0  #  5 west         insul_mtl_p
    5,    2  #  6 cor_j        gyp_blk_ptn
    5,    2  #  7 prt_ij       gyp_blk_ptn
    5,    2  #  8 str_2        gyp_blk_ptn
    5,    2  #  9 str_3        gyp_blk_ptn
    3,    0  # 10 east         insul_mtl_p
    5,    2  # 11 prt_gh       gyp_blk_ptn
    5,    2  # 12 prt_th       gyp_blk_ptn
    5,    2  # 13 prt_tcor     gyp_blk_ptn
    5,    2  # 14 prt_fcor     gyp_blk_ptn
    5,    1  # 15 upper        susp_flr_re
    1,    0  # 16 ceil         susp_ceil
    1,    0  # 17 cor_ceil     susp_ceil
    5,    1  # 18 up_cor       susp_flr_re
# air gap position & resistance for surface  2
  2,   0.170,
# air gap position & resistance for surface  3
  2,   0.170,
# air gap position & resistance for surface  4
  2,   0.170,
```

air gap position & resistance for surface 6
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 7
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 8
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 9
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 11
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 12
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 13
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 14
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 15
  3,   0.170,
air gap position & resistance for surface 18
  3,   0.170,

```
# conduc-  |  density | specific | thick- |dpnd|  ref. |  temp. |moisture| surf|lyr
# tivity   |          | heat     | ness(m)|type|  temp | factor | factor |     |
  210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #  1  1
    0.0400,     12.0,    840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
  210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
    0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  2  1
    0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
    0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
    0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  3  1
    0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
    0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
    0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  4  1
    0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
    0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
  210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #  5  1
    0.0400,     12.0,    840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
  210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  6  1
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  7  1
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  8  1
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  9  1
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
  210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  # 10  1
    0.0400,     12.0,    840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
  210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
```

```
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  # 11  1
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     2
   0.5100,   1400.0,   1000.0,  0.1000,   0,    0.00, 0.00000, 0.00000  #     3
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     4
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  #     5
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  # 12  1
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     2
   0.5100,   1400.0,   1000.0,  0.1000,   0,    0.00, 0.00000, 0.00000  #     3
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     4
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  #     5
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  # 13  1
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     2
   0.5100,   1400.0,   1000.0,  0.1000,   0,    0.00, 0.00000, 0.00000  #     3
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     4
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  #     5
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  # 14  1
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     2
   0.5100,   1400.0,   1000.0,  0.1000,   0,    0.00, 0.00000, 0.00000  #     3
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     4
   0.1900,    950.0,    840.0,  0.0130,   0,    0.00, 0.00000, 0.00000  #     5
  50.0000,   7800.0,    502.0,  0.0040,   0,    0.00, 0.00000, 0.00000  # 15  1
   1.4000,   2100.0,    653.0,  0.1400,   0,    0.00, 0.00000, 0.00000  #     2
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     3
   0.1500,    800.0,   2093.0,  0.0190,   0,    0.00, 0.00000, 0.00000  #     4
   0.0600,    186.0,   1360.0,  0.0060,   0,    0.00, 0.00000, 0.00000  #     5
   0.4200,   1200.0,    837.0,  0.0130,   0,    0.00, 0.00000, 0.00000  # 16  1
   0.4200,   1200.0,    837.0,  0.0130,   0,    0.00, 0.00000, 0.00000  # 17  1
  50.0000,   7800.0,    502.0,  0.0040,   0,    0.00, 0.00000, 0.00000  # 18  1
   1.4000,   2100.0,    653.0,  0.1400,   0,    0.00, 0.00000, 0.00000  #     2
   0.0000,      0.0,      0.0,  0.0500,   0,    0.00, 0.00000, 0.00000  #     3
   0.1500,    800.0,   2093.0,  0.0190,   0,    0.00, 0.00000, 0.00000  #     4
   0.0600,    186.0,   1360.0,  0.0060,   0,    0.00, 0.00000, 0.00000  #     5
```

for each surface: inside face emissivity
0.82 0.83 0.83 0.83 0.82 0.91 0.91 0.91 0.91 0.82 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.90
for each surface: outside face emissivity
0.82 0.83 0.83 0.83 0.82 0.91 0.91 0.91 0.91 0.82 0.91 0.91 0.91 0.91 0.12 0.91 0.91 0.12
for each surface: inside face solar absorptivity
0.32 0.05 0.05 0.05 0.32 0.22 0.22 0.22 0.22 0.32 0.22 0.22 0.22 0.22 0.60 0.50 0.50 0.60
for each surface: outside face solar absorptivity
0.72 0.05 0.05 0.05 0.72 0.22 0.22 0.22 0.22 0.72 0.22 0.22 0.22 0.22 0.20 0.50 0.50 0.20
inside and exterior glazing maintenance factors
1.00 1.00

```
# thermophysical properties of corid_1 defined in ../zones/corid_1.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    3,    0  #  1 west_cor     insul_mtl_p
    1,    0  #  2 door         door
    1,    0  #  3 prt_d-cor    mass_part
    5,    2  #  4 prt_t_cor    gyp_blk_ptn
    1,    0  #  5 door         door
    3,    1  #  6 ent_a        dbl_glz
    3,    1  #  7 ent_b        dbl_glz
```

```
    3,    1  #  8 ent_c       dbl_glz
    1,    0  #  9 ceil        susp_ceil
    5,    1  # 10 floor       susp_floor
    3,    1  # 11 ent_d       dbl_glz
    3,    1  # 12 glz_w       dbl_glz
    3,    1  # 13 door_dcor   dbl_glz
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  6
  2,   0.170,
# air gap position & resistance for surface  7
  2,   0.170,
# air gap position & resistance for surface  8
  2,   0.170,
# air gap position & resistance for surface 10
  3,   0.170,
# air gap position & resistance for surface 11
  2,   0.170,
# air gap position & resistance for surface 12
  2,   0.170,
# air gap position & resistance for surface 13
  2,   0.170,
```

```
# conduc-  |  density | specific | thick- |dpnd|  ref. |  temp. |moisture| surf|lyr
# tivity   |          | heat     | ness(m)|type|  temp | factor | factor |     |
   210.0000,    2700.0,     880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #  1  1
     0.0400,      12.0,     840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
   210.0000,    2700.0,     880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
     0.1900,     700.0,    2390.0,  0.0250,   0,   0.00, 0.00000, 0.00000  #  2  1
     0.5100,    1400.0,    1000.0,  0.2400,   0,   0.00, 0.00000, 0.00000  #  3  1
     0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  4  1
     0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,     700.0,    2390.0,  0.0250,   0,   0.00, 0.00000, 0.00000  #  5  1
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  6  1
     0.0000,       0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  7  1
     0.0000,       0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  8  1
     0.0000,       0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.4200,    1200.0,     837.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  9  1
     0.0600,     186.0,    1360.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 10  1
     0.1500,     800.0,    2093.0,  0.0190,   0,   0.00, 0.00000, 0.00000  #     2
     0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     3
     1.4000,    2100.0,     653.0,  0.1400,   0,   0.00, 0.00000, 0.00000  #     4
    50.0000,    7800.0,     502.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     5
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 11  1
     0.0000,       0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 12  1
     0.0000,       0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 13  1
     0.0000,       0.0,       0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,    2710.0,     837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
```

```
# for each surface: inside face emissivity
  0.82 0.90 0.90 0.91 0.90 0.83 0.83 0.83 0.91 0.12 0.83 0.83 0.83
# for each surface: outside face emissivity
  0.82 0.90 0.90 0.91 0.90 0.83 0.83 0.83 0.91 0.90 0.83 0.83 0.83
# for each surface: inside face solar absorptivity
  0.32 0.65 0.25 0.22 0.65 0.05 0.05 0.05 0.50 0.20 0.05 0.05 0.05
# for each surface: outside face solar absorptivity
  0.72 0.65 0.25 0.22 0.65 0.05 0.05 0.05 0.50 0.60 0.05 0.05 0.05
# inside and exterior glazing maintenance factors
   1.00   1.00
```

```
# thermophysical properties of corid_g defined in ../zones/corid_g.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
     3,     0  #  1 west_cor     insul_mtl_p
     1,     0  #  2 door         door
     1,     0  #  3 prt_i_cor    mass_part
     5,     2  #  4 prt_t_cor    gyp_blk_ptn
     1,     0  #  5 door_f       door
     3,     1  #  6 ent_a        dbl_glz
     3,     1  #  7 ent_b        dbl_glz
     3,     1  #  8 ent_c        dbl_glz
     1,     0  #  9 ceil         susp_ceil
     4,     0  # 10 floor        entry_floor
     3,     1  # 11 ent_d        dbl_glz
     3,     1  # 12 glz_w        dbl_glz
     3,     1  # 13 door_icor    dbl_glz
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  6
  2,   0.170,
# air gap position & resistance for surface  7
  2,   0.170,
# air gap position & resistance for surface  8
  2,   0.170,
# air gap position & resistance for surface 11
  2,   0.170,
# air gap position & resistance for surface 12
  2,   0.170,
# air gap position & resistance for surface 13
  2,   0.170,
```

```
# conduc-  |  density | specific | thick- |dpnd|  ref. |  temp. |moisture| surf|lyr
# tivity   |          | heat     | ness(m)|type|  temp | factor | factor |     |
   210.0000,   2700.0,     880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #  1  1
     0.0400,     12.0,     840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
   210.0000,   2700.0,     880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
     0.1900,    700.0,    2390.0,  0.0250,   0,   0.00, 0.00000, 0.00000  #  2  1
     0.5100,   1400.0,    1000.0,  0.2400,   0,   0.00, 0.00000, 0.00000  #  3  1
     0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  4  1
```

```
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    700.0,   2390.0,  0.0250,   0,   0.00, 0.00000, 0.00000  #  5  1
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  6  1
     0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  7  1
     0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #  8  1
     0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.4200,   1200.0,    837.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  9  1
     1.2800,   1460.0,    879.0,  0.2500,   0,   0.00, 0.00000, 0.00000  # 10  1
     0.5200,   2050.0,    184.0,  0.1500,   0,   0.00, 0.00000, 0.00000  #     2
     1.4000,   2100.0,    653.0,  0.1500,   0,   0.00, 0.00000, 0.00000  #     3
     2.0000,   2500.0,    880.0,  0.0240,   0,   0.00, 0.00000, 0.00000  #     4
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 11  1
     0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 12  1
     0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  # 13  1
     0.0000,      0.0,      0.0,  0.0120,   0,   0.00, 0.00000, 0.00000  #     2
     0.7600,   2710.0,    837.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     3
```

```
# for each surface: inside face emissivity
  0.82 0.90 0.90 0.91 0.90 0.83 0.83 0.83 0.91 0.90 0.83 0.83 0.83
# for each surface: outside face emissivity
  0.82 0.90 0.90 0.91 0.90 0.83 0.83 0.83 0.91 0.90 0.83 0.83 0.83
# for each surface: inside face solar absorptivity
  0.32 0.65 0.25 0.22 0.65 0.05 0.05 0.05 0.50 0.46 0.05 0.05 0.05
# for each surface: outside face solar absorptivity
  0.72 0.65 0.25 0.22 0.65 0.05 0.05 0.05 0.50 0.85 0.05 0.05 0.05
# inside and exterior glazing maintenance factors
   1.00   1.00
```

```
# thermophysical properties of roof defined in ../zones/roof.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name      | database name
    4,     1  #  1 south        roof
    4,     1  #  2 east         roof
    4,     1  #  3 north        roof
    4,     1  #  4 west         roof
    1,     0  #  5 ceil_c       susp_ceil
    1,     0  #  6 ceil_e       susp_ceil
    1,     0  #  7 stair_de     susp_ceil
    1,     0  #  8 ceil_t       susp_ceil
    1,     0  #  9 ceil_a       susp_ceil
    1,     0  # 10 stair_ab     susp_ceil
    1,     0  # 11 corid_c      susp_ceil
    3,     0  # 12 sofit        insul_mtl_p
    4,     1  # 13 ent_r_n      roof
    4,     1  # 14 ent_r_w      roof
```

4,   1 # 15 ent_r_s   roof
1,   0 # 16 ceil_b   susp_ceil
air gap position & resistance for surface 1
2,   0.170,
air gap position & resistance for surface 2
2,   0.170,
air gap position & resistance for surface 3
2,   0.170,
air gap position & resistance for surface 4
2,   0.170,
air gap position & resistance for surface 13
2,   0.170,
air gap position & resistance for surface 14
2,   0.170,
air gap position & resistance for surface 15
2,   0.170,

# conduc- tivity	density	specific heat	thick- ness(m)	dpnd type	ref. temp	temp. factor	moisture factor	surf	lyr
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 1	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 2	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 3	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 4	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 5	1
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 6	1
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 7	1
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 8	1
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 9	1
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 10	1
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 11	1
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	# 12	1
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	2
210.0000,	2700.0,	880.0,	0.0040,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 13	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 14	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	# 15	1
0.0000,	0.0,	0.0,	0.0250,	0,	0.00,	0.00000,	0.00000	#	2
0.0400,	12.0,	840.0,	0.0800,	0,	0.00,	0.00000,	0.00000	#	3
210.0000,	2700.0,	880.0,	0.0030,	0,	0.00,	0.00000,	0.00000	#	4
0.4200,	1200.0,	837.0,	0.0130,	0,	0.00,	0.00000,	0.00000	# 16	1

for each surface: inside face emissivity
0.22 0.22 0.22 0.22 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.82 0.22 0.22 0.22 0.91
for each surface: outside face emissivity
0.22 0.22 0.22 0.22 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.82 0.22 0.22 0.22 0.91

```
# for each surface: inside face solar absorptivity
  0.20 0.20 0.20 0.20 0.50 0.50 0.50 0.50 0.50 0.50 0.50 0.32 0.20 0.20 0.20 0.50
# for each surface: outside face solar absorptivity
  0.20 0.20 0.20 0.20 0.50 0.50 0.50 0.50 0.50 0.50 0.50 0.72 0.20 0.20 0.20 0.50
# inside and exterior glazing maintenance factors
   1.00   1.00



# thermophysical properties of stair_abfg defined in ../zones/stair_abfg.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name      | database name
     3,     0  #  1 east        insul_mtl_p
     5,     2  #  2 prt_f       gyp_blk_ptn
     5,     2  #  3 prt_f1      gyp_blk_ptn
     5,     2  #  4 prt_g       gyp_blk_ptn
     5,     2  #  5 prt_g1      gyp_blk_ptn
     1,     0  #  6 ceil        susp_ceil
     6,     1  #  7 floor       grnd_floor
     5,     2  #  8 prt_gc1     gyp_blk_ptn
     5,     2  #  9 prt_b1      gyp_blk_ptn
     5,     2  # 10 prt_gc      gyp_blk_ptn
     5,     2  # 11 prt_b       gyp_blk_ptn
     5,     2  # 12 prt_ac1     gyp_blk_ptn
     5,     2  # 13 prt_a1      gyp_blk_ptn
     5,     2  # 14 prt_ac      gyp_blk_ptn
     5,     2  # 15 prt_a       gyp_blk_ptn
     1,     0  # 16 door        door
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  5
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  7
  4,   0.170,
# air gap position & resistance for surface  8
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  9
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface 10
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface 11
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface 12
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface 13
  2,   0.170, 4,   0.170,
```

air gap position & resistance for surface 14
2,   0.170, 4,   0.170,
air gap position & resistance for surface 15
2,   0.170, 4,   0.170,

```
# conduc-  |  density | specific | thick- |dpnd|  ref. |  temp. |moisture| surf|lyr
# tivity   |          | heat     | ness(m)|type|  temp | factor | factor |     |
  210.0000,   2700.0,     880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #  1  1
    0.0400,     12.0,     840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
  210.0000,   2700.0,     880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  2  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  3  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  4  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  5  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.4200,   1200.0,     837.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  6  1
    1.2800,   1460.0,     879.0,  0.2500,   0,   0.00, 0.00000, 0.00000  #  7  1
    0.5200,   2050.0,     184.0,  0.1500,   0,   0.00, 0.00000, 0.00000  #     2
    1.4000,   2100.0,     653.0,  0.1500,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1500,    800.0,    2093.0,  0.0190,   0,   0.00, 0.00000, 0.00000  #     5
    0.0600,    186.0,    1360.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     6
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  8  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  9  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 10  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 11  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 12  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 13  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 14  1
    0.0000,      0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
```

```
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 15  1
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
    0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
    0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
    0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
    0.1900,    700.0,   2390.0,  0.0250,   0,   0.00, 0.00000, 0.00000  # 16  1
# for each surface: inside face emissivity
  0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.90
# for each surface: outside face emissivity
  0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.90
# for each surface: inside face solar absorptivity
  0.32 0.22 0.22 0.22 0.22 0.50 0.60 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.65
# for each surface: outside face solar absorptivity
  0.72 0.22 0.22 0.22 0.22 0.50 0.85 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.65
# inside and exterior glazing maintenance factors
   1.00   1.00
```

```
# thermophysical properties of stair_deij defined in ../zones/stair_deij.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    3,    0  #  1 east         insul_mtl_p
    5,    2  #  2 prt_i        gyp_blk_ptn
    5,    2  #  3 prt_i1       gyp_blk_ptn
    5,    2  #  4 prt_j        gyp_blk_ptn
    5,    2  #  5 prt_j1       gyp_blk_ptn
    1,    0  #  6 ceil         susp_ceil
    6,    1  #  7 floor        grnd_floor
    5,    2  #  8 prt_cj1      gyp_blk_ptn
    5,    2  #  9 prt_e1       gyp_blk_ptn
    5,    2  # 10 prt_cj       gyp_blk_ptn
    5,    2  # 11 prt_e        gyp_blk_ptn
    5,    2  # 12 prt_ci1      gyp_blk_ptn
    5,    2  # 13 prt_d1       gyp_blk_ptn
    5,    2  # 14 prt_ci       gyp_blk_ptn
    5,    2  # 15 prt_d        gyp_blk_ptn
    1,    0  # 16 door         door
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  3
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  4
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  5
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  7
  4,   0.170,
# air gap position & resistance for surface  8
  2,   0.170, 4,   0.170,
```

air gap position & resistance for surface 9
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 10
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 11
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 12
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 13
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 14
  2,   0.170, 4,   0.170,
air gap position & resistance for surface 15
  2,   0.170, 4,   0.170,

```
# conduc-  |  density | specific | thick-  |dpnd|  ref. |  temp. |moisture| surf|lyr
# tivity   |          | heat     | ness(m)|type|  temp | factor | factor |     |
   210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #  1  1
     0.0400,     12.0,    840.0,  0.0800,   0,   0.00, 0.00000, 0.00000  #     2
   210.0000,   2700.0,    880.0,  0.0040,   0,   0.00, 0.00000, 0.00000  #     3
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  2  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  3  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  4  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  5  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.4200,   1200.0,    837.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  6  1
     1.2800,   1460.0,    879.0,  0.2500,   0,   0.00, 0.00000, 0.00000  #  7  1
     0.5200,   2050.0,    184.0,  0.1500,   0,   0.00, 0.00000, 0.00000  #     2
     1.4000,   2100.0,    653.0,  0.1500,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1500,    800.0,   2093.0,  0.0190,   0,   0.00, 0.00000, 0.00000  #     5
     0.0600,    186.0,   1360.0,  0.0060,   0,   0.00, 0.00000, 0.00000  #     6
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  8  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #  9  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 10  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     4
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #     5
     0.1900,    950.0,    840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 11  1
     0.0000,      0.0,      0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #     2
     0.5100,   1400.0,   1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #     3
```

```
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      4
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #      5
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 12   1
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      2
    0.5100,    1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #      3
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      4
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #      5
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 13   1
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      2
    0.5100,    1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #      3
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      4
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #      5
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 14   1
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      2
    0.5100,    1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #      3
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      4
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #      5
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  # 15   1
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      2
    0.5100,    1400.0,    1000.0,  0.1000,   0,   0.00, 0.00000, 0.00000  #      3
    0.0000,       0.0,       0.0,  0.0500,   0,   0.00, 0.00000, 0.00000  #      4
    0.1900,     950.0,     840.0,  0.0130,   0,   0.00, 0.00000, 0.00000  #      5
    0.1900,     700.0,    2390.0,  0.0250,   0,   0.00, 0.00000, 0.00000  # 16   1
```

```
# for each surface: inside face emissivity
 0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.90
# for each surface: outside face emissivity
 0.82 0.91 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.90
# for each surface: inside face solar absorptivity
 0.32 0.22 0.22 0.22 0.22 0.50 0.60 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.65
# for each surface: outside face solar absorptivity
 0.72 0.22 0.22 0.22 0.22 0.50 0.85 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.65
# inside and exterior glazing maintenance factors
  1.00   1.00
```

```
# thermophysical properties of toilets defined in ../zones/toilets.con
# no of |air |surface(from geo)| multilayer construction
# layers|gaps|  no.  name       | database name
    5,    2  #  1 prt_tcor     gyp_blk_ptn
    5,    2  #  2 prt_th       gyp_blk_ptn
    5,    2  #  3 prt_tg       gyp_blk_ptn
    5,    2  #  4 prt_ft       gyp_blk_ptn
    1,    0  #  5 ceiling      susp_ceil
    6,    1  #  6 floor        grnd_floor
    5,    2  #  7 prt_tcorc    gyp_blk_ptn
    5,    2  #  8 prt_tcor1    gyp_blk_ptn
    5,    2  #  9 prt_cth      gyp_blk_ptn
    5,    2  # 10 prt_ctc      gyp_blk_ptn
    5,    2  # 11 prt_ctb      gyp_blk_ptn
    5,    2  # 12 prt_tb       gyp_blk_ptn
    5,    2  # 13 prt_cat      gyp_blk_ptn
    5,    2  # 14 prt_ta       gyp_blk_ptn
# air gap position & resistance for surface  1
  2,   0.170, 4,   0.170,
# air gap position & resistance for surface  2
  2,   0.170, 4,   0.170,
```

air gap position & resistance for surface 3
2,   0.170, 4,   0.170,
air gap position & resistance for surface 4
2,   0.170, 4,   0.170,
air gap position & resistance for surface 6
4,   0.170,
air gap position & resistance for surface 7
2,   0.170, 4,   0.170,
air gap position & resistance for surface 8
2,   0.170, 4,   0.170,
air gap position & resistance for surface 9
2,   0.170, 4,   0.170,
air gap position & resistance for surface 10
2,   0.170, 4,   0.170,
air gap position & resistance for surface 11
2,   0.170, 4,   0.170,
air gap position & resistance for surface 12
2,   0.170, 4,   0.170,
air gap position & resistance for surface 13
2,   0.170, 4,   0.170,
air gap position & resistance for surface 14
2,   0.170, 4,   0.170,

```
# conduc-  |  density | specific | thick- |dpnd|  ref. |  temp. |moisture| surf|lyr
# tivity   |          | heat     | ness(m)|type|  temp |  factor | factor |     |
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  1  1
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #     5
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  2  1
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #     5
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  3  1
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #     5
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  4  1
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #     5
     0.4200,    1200.0,     837.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  5  1
     1.2800,    1460.0,     879.0,  0.2500,    0,   0.00, 0.00000, 0.00000  #  6  1
     0.5200,    2050.0,     184.0,  0.1500,    0,   0.00, 0.00000, 0.00000  #     2
     1.4000,    2100.0,     653.0,  0.1500,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1500,     800.0,    2093.0,  0.0190,    0,   0.00, 0.00000, 0.00000  #     5
     0.0600,     186.0,    1360.0,  0.0060,    0,   0.00, 0.00000, 0.00000  #     6
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  7  1
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #     5
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #  8  1
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     2
     0.5100,    1400.0,    1000.0,  0.1000,    0,   0.00, 0.00000, 0.00000  #     3
     0.0000,       0.0,       0.0,  0.0500,    0,   0.00, 0.00000, 0.00000  #     4
     0.1900,     950.0,     840.0,  0.0130,    0,   0.00, 0.00000, 0.00000  #     5
```

```
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #  9  1
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     2
0.5100,  1400.0,  1000.0, 0.1000,  0,  0.00, 0.00000, 0.00000  #     3
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     4
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #     5
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  # 10  1
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     2
0.5100,  1400.0,  1000.0, 0.1000,  0,  0.00, 0.00000, 0.00000  #     3
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     4
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #     5
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  # 11  1
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     2
0.5100,  1400.0,  1000.0, 0.1000,  0,  0.00, 0.00000, 0.00000  #     3
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     4
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #     5
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  # 12  1
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     2
0.5100,  1400.0,  1000.0, 0.1000,  0,  0.00, 0.00000, 0.00000  #     3
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     4
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #     5
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  # 13  1
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     2
0.5100,  1400.0,  1000.0, 0.1000,  0,  0.00, 0.00000, 0.00000  #     3
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     4
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #     5
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  # 14  1
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     2
0.5100,  1400.0,  1000.0, 0.1000,  0,  0.00, 0.00000, 0.00000  #     3
0.0000,     0.0,     0.0, 0.0500,  0,  0.00, 0.00000, 0.00000  #     4
0.1900,   950.0,   840.0, 0.0130,  0,  0.00, 0.00000, 0.00000  #     5
```

```
# for each surface: inside face emissivity
 0.91 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.91
# for each surface: outside face emissivity
 0.91 0.91 0.91 0.91 0.91 0.90 0.91 0.91 0.91 0.91 0.91 0.91 0.91 0.91
# for each surface: inside face solar absorptivity
 0.22 0.22 0.22 0.22 0.50 0.60 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22
# for each surface: outside face solar absorptivity
 0.22 0.22 0.22 0.22 0.50 0.85 0.22 0.22 0.22 0.22 0.22 0.22 0.22 0.22
# inside and exterior glazing maintenance factors
  1.00   1.00
```

9.1.5 Operation files (.opr)

```
# operations of ceil_j defined in:
# ../zones/opr/ceiling.opr
ceilings         # operation name
# control(no control of air flow  ), low & high setpoints
  0    0.000    0.000
    0   # no Weekday flow periods
    0   # no Saturday flow periods
    0   # no Sunday flow periods
    2   # no Weekday casual gains
# Wkd: type, start, stop, sens, latent, rad_frac, conv_frac
   2,   1,  24,     50.0,      0.0, 0.600, 0.400
   2,   8,  18,   1275.0,    700.0, 0.600, 0.400
    1   # no Saturday casual gains
# Sat: type, start, stop, sens, latent, rad_frac, conv_frac
```

```
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
     1   # no Sunday casual gains
# Sun: type, start, stop, sens, latent, rad_frac, conv_frac
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
# Labels for gain types
 Occupt Lights Equipt



# operations of toilets defined in:
# ../zones/opr/entry.opr
entry              # operation name
# control(no control of air flow  ), low & high setpoints
   0     0.000     0.000
     2   # no Weekday flow periods
# Wkd: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     2   # no Saturday flow periods
# Sat: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     2   # no Sunday flow periods
# Sun: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     3   # no Weekday casual gains
# Wkd: type, start, stop, sens, latent, rad_frac, conv_frac
    1,   1,  24,    100.0,     70.0, 0.200, 0.800
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
    2,   8,  18,    200.0,      0.0, 0.600, 0.400
     1   # no Saturday casual gains
# Sat: type, start, stop, sens, latent, rad_frac, conv_frac
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
     1   # no Sunday casual gains
# Sun: type, start, stop, sens, latent, rad_frac, conv_frac
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
# Labels for gain types
 Occupt Lights Equipt



# operations for silly spaces defined in:
# nil.opr
# operation name
nil
# control(no flow control         ), low & high setpoints
   0     0.000     0.000
     0   # no weekday flow periods
     0   # no Saturday flow periods
```

```
    0   # no Sunday flow periods
    0   # no weekday casual gains
    0   # no Saturday casual gains
    0   # no Sunday casual gains



# operations of Unit_e defined in:
# ../zones/opr/occup_offices.opr
ocup_off         # operation name
# control(no control of air flow  ), low & high setpoints
  0     0.000     0.000
    2   # no Weekday flow periods
# Wkd: start, stop, infil, ventil, source, data
  1, 24,    0.500    0.000    0    0.000
  7, 18,    1.000    0.000    0    0.000
    2   # no Saturday flow periods
# Sat: start, stop, infil, ventil, source, data
  1, 24,    0.500    0.000    0    0.000
  7, 18,    1.000    0.000    0    0.000
    2   # no Sunday flow periods
# Sun: start, stop, infil, ventil, source, data
  1, 24,    0.500    0.000    0    0.000
  7, 18,    1.000    0.000    0    0.000
    6   # no Weekday casual gains
# Wkd: type, start, stop, sens, latent, rad_frac, conv_frac
   3,   1,  24,    100.0,     40.0, 0.500, 0.500
   3,   8,  18,    600.0,      0.0, 0.400, 0.600
   2,   1,  24,    100.0,      0.0, 0.600, 0.400
   2,   8,  18,   2550.0,      0.0, 0.600, 0.400
   1,   1,  24,      0.0,      0.0, 0.500, 0.500
   1,   8,  18,   1343.0,    637.0, 0.200, 0.800
    3   # no Saturday casual gains
# Sat: type, start, stop, sens, latent, rad_frac, conv_frac
   3,   1,  24,    100.0,     40.0, 0.500, 0.500
   2,   1,  24,    100.0,      0.0, 0.600, 0.400
   1,   8,  18,    100.0,     70.0, 0.200, 0.800
    3   # no Sunday casual gains
# Sun: type, start, stop, sens, latent, rad_frac, conv_frac
   3,   1,  24,    100.0,     40.0, 0.500, 0.500
   2,   1,  24,    100.0,      0.0, 0.600, 0.400
   1,   8,  18,    100.0,     70.0, 0.200, 0.800
# Labels for gain types
 Occupt Lights Equipt



# operations of Unit_b defined in:
# ../zones/opr/offices_bg.opr
small_off        # operation name
```

```
# control(no control of air flow  ), low & high setpoints
   0     0.000     0.000
     2   # no Weekday flow periods
# Wkd: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     2   # no Saturday flow periods
# Sat: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     2   # no Sunday flow periods
# Sun: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     6   # no Weekday casual gains
# Wkd: type, start, stop, sens, latent, rad_frac, conv_frac
    3,   1,  24,    100.0,     40.0, 0.500, 0.500
    3,   8,  18,    600.0,      0.0, 0.400, 0.600
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
    2,   8,  18,   1940.0,      0.0, 0.600, 0.400
    1,   1,  24,      0.0,      0.0, 0.500, 0.500
    1,   8,  18,   1032.0,    500.0, 0.200, 0.800
     3   # no Saturday casual gains
# Sat: type, start, stop, sens, latent, rad_frac, conv_frac
    3,   1,  24,    100.0,     40.0, 0.500, 0.500
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
    1,   8,  18,    100.0,     70.0, 0.200, 0.800
     3   # no Sunday casual gains
# Sun: type, start, stop, sens, latent, rad_frac, conv_frac
    3,   1,  24,    100.0,     40.0, 0.500, 0.500
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
    1,   8,  18,    100.0,     70.0, 0.200, 0.800
# Labels for gain types
 Occupt Lights Equipt



# operations of roof defined in:
# ../zones/opr/roof.opr
roof              # operation name
# control(no control of air flow  ), low & high setpoints
   0     0.000     0.000
     1   # no Weekday flow periods
# Wkd: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
     1   # no Saturday flow periods
# Sat: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
     1   # no Sunday flow periods
# Sun: start, stop, infil, ventil, source, data
```

```
   1, 24,    0.500    0.000    0    0.000
     2   # no Weekday casual gains
# Wkd: type, start, stop, sens, latent, rad_frac, conv_frac
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
    2,   8,  18,   6000.0,    700.0, 0.600, 0.400
     1   # no Saturday casual gains
# Sat: type, start, stop, sens, latent, rad_frac, conv_frac
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
     1   # no Sunday casual gains
# Sun: type, start, stop, sens, latent, rad_frac, conv_frac
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
# Labels for gain types
 Occupt Lights Equipt



# operations of Unit_cd defined in:
# ../zones/opr/unoccup_offices.opr
unocp_of         # operation name
# control(no control of air flow  ), low & high setpoints
   0     0.000     0.000
     2   # no Weekday flow periods
# Wkd: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     2   # no Saturday flow periods
# Sat: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     2   # no Sunday flow periods
# Sun: start, stop, infil, ventil, source, data
   1, 24,    0.500    0.000    0    0.000
   7, 18,    1.000    0.000    0    0.000
     3   # no Weekday casual gains
# Wkd: type, start, stop, sens, latent, rad_frac, conv_frac
    3,   1,  24,    100.0,     40.0, 0.500, 0.500
    2,   1,  24,    100.0,      0.0, 0.600, 0.400
    1,   1,  24,      0.0,      0.0, 0.500, 0.500
     3   # no Saturday casual gains
# Sat: type, start, stop, sens, latent, rad_frac, conv_frac
    3,   1,  24,     50.0,     40.0, 0.500, 0.500
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
    1,   8,  18,     50.0,     70.0, 0.200, 0.800
     3   # no Sunday casual gains
# Sun: type, start, stop, sens, latent, rad_frac, conv_frac
    3,   1,  24,     50.0,     40.0, 0.500, 0.500
    2,   1,  24,     50.0,      0.0, 0.600, 0.400
    1,   8,  18,     50.0,     70.0, 0.200, 0.800
# Labels for gain types
 Occupt Lights Equipt
```

9.1.6 Transparent Constructions files (.tmc)

```
# transparent properties of Unit_a defined in ../zones/Unit_a.tmc
 13   # surfaces
# tmc index for each surface
 0  0  0  0  0  0  0  0  0  0  1  1  1
  3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
  0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
  0.157   0.172   0.185   0.201   0.202
  0.001   0.002   0.003   0.004   0.005
  0.117   0.124   0.127   0.112   0.077
  0  # blind/shutter control flag
```

```
# transparent properties of Unit_b defined in ../zones/Unit_b.tmc
  9   # surfaces
# tmc index for each surface
 0  0  0  0  0  0  0  0  1
  3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
  0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
  0.157   0.172   0.185   0.201   0.202
  0.001   0.002   0.003   0.004   0.005
  0.117   0.124   0.127   0.112   0.077
  0  # blind/shutter control flag
```

```
# transparent properties of Unit_cd defined in ../zones/Unit_cd.tmc
 13   # surfaces
# tmc index for each surface
 0  0  0  0  0  0  0  0  0  1  1  0  0
  3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
  0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
  0.157   0.172   0.185   0.201   0.202
  0.001   0.002   0.003   0.004   0.005
  0.117   0.124   0.127   0.112   0.077
  0  # blind/shutter control flag
```

```
# transparent properties of Unit_e defined in ../zones/Unit_e.tmc
  12   # surfaces
# tmc index for each surface
  0  0  0  0  0  0  0  0  0  1  1  1
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of Unit_f defined in ../zones/Unit_f.tmc
  13   # surfaces
# tmc index for each surface
  0  0  0  0  0  0  0  0  0  0  1  1  1
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of Unit_g defined in ../zones/Unit_g.tmc
   9   # surfaces
# tmc index for each surface
  0  0  0  0  0  0  0  0  1
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of Unit_hi defined in ../zones/Unit_hi.tmc
  13   # surfaces
# tmc index for each surface
  0  0  0  0  0  0  0  0  0  1  1  0  0
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of Unit_j defined in ../zones/Unit_j.tmc
  12   # surfaces
# tmc index for each surface
  0  0  0  0  0  0  0  0  0  1  1  1
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of ceil_chi defined in ../zones/ceil_chi.tmc
  18   # surfaces
# tmc index for each surface
  0  1  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of corid_1 defined in ../zones/corid_1.tmc
  13   # surfaces
# tmc index for each surface
  0  0  0  0  0  1  1  1  0  0  1  1  1
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```

```
# transparent properties of corid_g defined in ../zones/corid_g.tmc
  13   # surfaces
# tmc index for each surface
  0  0  0  0  0  1  1  1  0  0  1  1  1
   3  DCF7671_06nb # layers in tmc type 1
# Transmission @ 5 angles & visible tr.
   0.611   0.583   0.534   0.384   0.170   0.760
# For each layer absorption @ 5 angles
   0.157   0.172   0.185   0.201   0.202
   0.001   0.002   0.003   0.004   0.005
   0.117   0.124   0.127   0.112   0.077
   0  # blind/shutter control flag
```