Handbook on structural timber design to Eurocode 5 (IS EN 1995-1-1) rules including strength capacity tables for structural elements

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Foreword

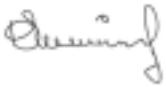
Construction in Ireland has grown beyond all expectations over the past decade. All components of the industry have shared in the boom, from commercial property to dwellings, to roads and other infrastructure. Building and construction now account for one fifth of all economic activity – not surprising, given that over 81,000 dwellings were completed in 2004 – an all time record that puts Ireland at the top of the European league table.

Wood product sales have grown in tandem with the building boom. One sector in particular – timber frame – has mushroomed from being an insignificant player in construction less than a decade ago, to where a quarter of all new dwellings are timber structures. Timber frame use continues to grow, with informed analysts predicting that it will soon become as common as traditional block build. There are many reasons to expect such a market share – not least the growing use of off-site construction, and the new EC Directive on the Energy Performance of Buildings.

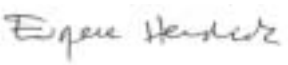
Versatility and energy performance are not the only reasons why the use of timber construction is likely to further expand. Confidence in the structural performance of wood has greatly increased. Underpinning this development are the many new CEN timber standards, in key areas such as strength classification of sawn timber. Engineers and architects can now specify using the CEN standards, under a common design approach that is set out in *Eurocode 5 Design of Timber Structures*, now an Irish standard. EC5 and the other Eurocodes, which form a set of harmonised structural design codes for building and civil engineering works, will soon become a key part of enabling works to comply with the requirements of the EC's Construction Products Directive.

This handbook is therefore a timely publication. It sets out in substantial detail the basis of the EC 5 approach, and its underlying limit state design philosophy. Each CEN standard called up in the code is comprehensively dealt with, as are material properties, such as strength and stiffness characteristic values, and durability.

In conclusion COFORD congratulates the authors, Jim Harrington, Malcolm Jacob and Colin Short, for putting together under a COFORD-funded project, what will no doubt become a standard reference work for the design of timber structures in Ireland. We are confident it will contribute to the greater use of wood in construction, particularly in the commercial building sector, where timber has a very significant untapped potential.



David Nevins
Chairman



Dr Eugene Hendrick
Director

Brollach

Tháinig borradh ar thógáil in Éirinn a bhí i bhfad chun tosaigh ar ionchas cách i rith an deich mbliana seo caite. Bhain gach eilimint sa tionscal tairbhe as an mborradh, idir maoin tráchtála, teaghaisí, bóithre agus bonneagar eile . Anois tá tógáil freagrach as cúigiú de ghníomhaíocht eacnamaíoch ar fad – níl aon ionadh, agus 81,000 teaghais críochnaithe i 2004 – curiarracht amach is amach a chuireann Éire ar bharr clár léige na hEorpa.

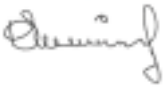
Tháinig borradh ar dhíolachán táirgí adhmaid i dteannta leis an mborradh ar thógáil. D'eascair earnáil amháin faoi leith – fráma adhmaid – ó ról beag a bheith acu i dtógáil níos lú ná deich mbliana ó sin, go aimsir nuair atá ceathrú de theaghaisí nua go léir ina struchtúir adhmaid. Tá úsáid fráma adhmaid fós ag méadú, tuarann anailísithe eolasacha go mbeidh sé chomh coitianta le hábhar tógála bloic traidisiúnta. Tá go leor cúiseanna le bheith ag súil le scair margaidh dá leithéid, ar cheann de na cúiseanna móra tá úsáid méadaithe tógála amach ón láthair, agus an Treoir AE nua ar Fheidhmiú Fuinnimh Foirgneamh .

Ní hiad ilchumas agus feidhmiú fuinnimh na cúiseanna amháin gur cosúil go dtiocfaidh tuilleadh méadaithe ar úsáid tógáil adhmaid. Tháinig méadú mór ar an muinín as feidhmiú struchtúrtha an adhmaid. Ag tacú leis an bhforbairt seo tá go leor caighdeán adhmaid CEN nua, i bpríomhréimsí mar rangú neart adhmaid sáfa. Anois is féidir le hinnealtóirí agus ailtirí sonrú agus úsáid á bhaint acu as caighdeán CEN, faoi chur chuige coitianta i dtreo dearaidh atá leagtha amach i *Eurocode 5 Design of Timber Structures*, ar caighdeán Éireannach e anois. Beidh príomhról ag EC5 agus na Eurocóid eile, atá ina sraith cód dearaidh structúrtha a fhreagraíonn dá chéile d'oibreach tógála agus innealtóireachta sibhialta, i gcur ar chumas oibreacha géilleadh do riachtanais Treoir an CE i leith Táirgí Tógála.

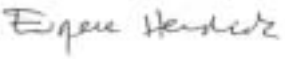
Mar sin foilseachán tráthúil atá sa lámhleabhar seo Leagann sé amach go mionsonrach bunús an chur chuige EC 5 agus an fhealsúnacht teorainn dearadh stáit atá taobh thiar de. Pléitear go cuimsitheach gach

caighdeán CEN a ghlaoitear air sa chód, mar a phléitear airíonna ábhair, mar neart agus luachanna sainiúla doichte agus marthanacht.

Mar chonclúid déanann COFORD comhghairdeas leis na húdair, Jim Harrington, Malcom Jacob agus Colin Short, as ucht tionscadal atá maoinithe ag COFORD a chur le chéile, a bheidh gan amhras ina shaothar tagartha caighdeánach do dhearadh struchtúir adhmaid in Éirinn. Táimid cinnte go gcuirfidh sé le húsáid níos mó adhmaid i dtógáil, go háirithe in earnáil na tógála tráchtála, áit a bhfuil deis mhór ag adhmad nár baineadh tairbhe as fós.



David Nevins
Cathaoirleach



Dr Eugene Hendrick
Stiúrthóir

Preface

The first code of practice issued in the United Kingdom (UK) on the structural use of timber was CP 112 of 1952. It was based on research and experience of Canadian, United States and British war-time construction. It enabled the construction industry in the UK to build timber structures and use timber structural elements for a period of fifteen years without serious challenge to its validity. Over the period of use it became evident that its main difficulty lay in it being overtaken by research and experience in the UK and overseas. Its first revision was published by the British Standards Institution in 1967. The significant changes to the original code consisted of addition of new data in regard to grades of timber for use, development of glued laminated construction and the structural use of plywood. This 1967 version referenced eight British standards and two British codes of practice: CP 3 which dealt with basic data for the design of buildings and also loadings; and CP 98 which set out the requirements for preservative treatment for constructional timber.

The first handbook which provided background information on the provisions of the 1967 edition of CP 112 was *The Structural Use of Timber* by Booth and Reece which was published in 1967. There was no such aid for the first edition of CP 112. L.G. Booth was a member of the CP 112 code drafting committee for *The Structural Use of Timber in Buildings* for which the Institution of Structural Engineers provided the Secretariat. The first edition of a *Timber Designers' Manual* in the UK was written by J.A. Baird and E.C. Ozelton in 1976. The foreword to that edition was provided by J.G. Sunley, Chairman of the Code of Practice on the Structural Use of Timber.

This handbook has been prepared so that Eurocode 5: Part 1-1 may be used at an early date, rather than await the time when it is no longer acceptable to use the current codes of practice which are at present used for the design of timber structures in Ireland. Eurocode 5 (EC5) relies for implementation on a number of other Eurocodes and on a very large number of material and production standards. The handbook sets out the

manner in which IS EN 1995-1-1 and other Eurocodes interact in the design process. It indicates and includes information, in a summarised manner, the standards which are required to be used, in order to facilitate the implementation of the design principles and application rules of EC5. Without such information the Eurocode would not be design functional.

There are at the present time a number of the normative standards within the revision process being undertaken by CEN-European Committee for Standardisation. There are also a number of requirements in these standards which have been challenged for validity in the context of recent structural failures in Member States of the European Union. Such matters are currently receiving attention in the context of compilation of load-capacity tables for structural elements.

The handbook is for use by professional design engineers in the public and private sectors who are involved with design and/or construction of timber elements, assemblies and/or timber structures. It also provides the basic information for management in entities producing and/or manufacturing structural solid timber, glued laminated timber, laminated veneer lumber, wood-based panels, metal fasteners and prefabricated wall, floor and roof diaphragm elements. It will enable design engineers, architects and specifiers to use tabulated information relevant for timber construction. Academic staff at third level colleges and institutes will have the prerequisite information for the development of a syllabus for the introduction and use of Eurocode 5: Part 1-1 at undergraduate level and for the undertaking of relevant research at postgraduate programme level. Officers of regulatory and approving authorities will have available the benefit of the information provided in the handbook.

Réamhrá

Ba é an chéad cód cleachtais a d'eisíodh sa Ríocht Aontaithe (RA) ar úsáid adhmaid struchtúrtha ná CP 112 ó 1952. Bhí sé bunaithe ar thaighde agus thaithí tógáil aimsir chogaidh Cheanada, na Stát Aontaithe agus na Breataine. Chuir sé ar chumas an tionscal tógála san RA struchtúir adhmaid a thógáil agus eilimintí struchtúrtha adhmaid a úsáid ar feadh tréimhse cúig bliana déag gan dúshlán mór roimh a bhailíocht. Thar an tréimhse úsáide tuigeadh gurb í an phríomhdheacracht ná go raibh taighde agus taithí san RA agus thar lear ag teacht suas leis. D'fhoilsigh an British Standards Institution an chéad athbhreithniú air i 1967. Ba iad na hathruithe móra ar an mbunchód ná cur isteach sonraí nua maidir le gráid adhmaid le haghaidh úsáide, forbairt tógáil glaeite lannaithe agus úsáid struchtúrtha sraithadhmaid. Rinne an leagan seo ó 1967 tagairt d'ocht gcaighdeán Briotanach agus dhá chód cleachtais Briotanach: CP 3 a phléigh le sonraí bunúsach do dhearadh foirgneamh agus lastálacha freisin; agus CP 98 a leag amach na riachtanais do chóireáil caomhnaithe d'adhmad tógála.

Ba é an chéad lámhleabhar a chuir eolas cúlra ar fhorálacha eagrán 1967 CP 112 ar fáil ná *The Structural Use of Timber* le Booth agus Reece a d'fhoilsíodh i 1967. Ní raibh aon chúnamh dá leithéid do chéad eagrán CP 112. L.G. Bhí Booth ina bhall de choiste dréachtaithe cóid CP 112 le haghaidh *The Structural Use of Timber in Buildings* dár chuir an Institute of Structural Engineers Rúnaí ar fáil. Scríobh J.A. Baird agus E.C. Ozelten *Timber Designers' Manual* san RA i 1976. Chuir J.G. Sunley, Cathaoirleach an Chóid Chleachtaidh um Úsáid Struchtúrtha Adhmaid an réamhrá ar fáil .

Réitíodh an lámhleabhar seo ionas gur féidir Eurocód 5: Cuid 1-1 a úsáid go luath, in áit fanacht le ham nuair nach mbeidh sé inghlactha a thuilleadh na cóid cleachtais reatha a úsáidtear faoi láthair le haghaidh dearadh struchtúir adhmaid in Éirinn a úsáid. Braitheann Eurocód 5 (EC5) ar roinnt Eurocóid eile le haghaidh cur i bhfeidhm agus ar líon mór caighdeán ábhair agus táirgthe. Leagann an lámhleabhar amach an bealach ina idirghníomhaíonn IS EN 1995-1-1 agus Eurocóid eile sa

phróiseas dearaidh. Comharthaíonn sé agus tógann sé san áireamh eolas, ar bhealach coimrithe, na caighdeáin nach mór úsáid, chun cur i bhfeidhm na prionsabail dearaidh agus rialacha feidhmiúcháin EC5 a éascú. Gan an t-eolas sin ní féidir leis an Eurocód feidhmiú.

Faoi láthair tá roinnt caighdeán normatach sa phróiseas athbhreithnithe atá á dhéanamh ag CEN – Coiste Eorpach um Chaighdeánú. Freisin tá roinnt caighdeán a cuireadh dúshlán roimh a mbailíocht i gcomhthéacs teipeanna struchtúrtha ag Ballstáit an Aontais Eorpaigh le déanaí. Faoi láthair táthar ag breathnú ar chúrsaí dá leithéid i gcomhthéacs cuimsiú clár toilleadh ualaigh d'eilimintí struchtúrtha.

Is le haghaidh úsáide ag innealtóirí dearaidh gairmiúla sna hearnálacha poiblí agus príobháideach atá i mbun dearadh agus/nó tógáil eilimintí adhmaid, coimeálacha agus/nó struchtúir adhmaid atá an lámhleabhar seo. Freisin soláthraíonn sé an t-eolas bunúsach do bhainistíocht in aonáin ag táirgeadh agus/nó ag déanamh adhmad déantúsaíochta struchtúrtha soladach, adhmad glaeite lannaithe, adhmad lannaithe veiníre, painéil le boinn adhmaid, dúntóirí miotail agus balla réamhdhéanta, eilimintí spiara urláir agus dín. Cuireann sé ar chumas innealtóirí dearaidh, ailtirí agus sonraitheoirí eolas táblaithe a úsáid chun méideanna eiliminte sonraithe a roghnú le haghaidh tógáil foirgneamh. Beidh an t-eolas réamhriachtanach d'fhorbairt siollabais le haghaidh tabhairt isteach agus úsáid Eurocód 5: Cuid 1-1 ag leibhéal fochéime agus le haghaidh tabhairt faoi thaighde ábhartha ag leibhéal clár iarchéime. Beidh tairbhe an eolais a chuirtear ar fáil sa lámhleabhar ag oifigigh údaráis rialúcháin agus/nó údaráis ceadaithe.

Contents

Section 1: General

1.01 Eurocode 5 (IS EN 1995-1-1) in the EU

Eurocode 5: *Design of timber structures* — Part 1-1: *General — Common rules and rules for buildings* was published by CEN (European Committee for Standardisation) in November 2004. National standards bodies in each member state of the EU and EFTA countries are obliged to give this European standard the status of a national standard without any alteration. In Ireland the responsibility for publication is with the National Standards Authority of Ireland. Eurocode 5 is referenced as EN 1995: *Design of timber structures*, and consists of Part 1-1 as described, Part 1-2: *General rules — Structural fire design* and Part 2: *Bridges*. EN 1995 is intended to be used in conjunction with:

- EN 1990: *2002 Eurocode — Basis of design*
- EN 1991: *Eurocode 1 — Actions on structures*
- EN Standards: in respect of construction products relevant to timber structures.

1.02 Basis of design - IS EN 1990 Eurocode 1990

The basis of design of timber structures as applied in EN 1995 is required to be in accordance with EN 1990 which sets out the principles and requirements for safety, serviceability and durability of structures, describes the design and verification procedures and provides guidelines for related aspects of structural reliability. The general assumptions of EN 1990 are:

- the choice of the structural system and the design of the structure is made by appropriately qualified and experienced personnel.
- execution is undertaken by personnel having the appropriate skill and experience.

- adequate supervision and quality control is provided during execution of the work, i.e. in design offices, factories, production and fabrication plants, and on site.
- the construction materials and products are used as specified in EN 1990 or in EN 1991 and in Eurocodes EN 1992 to EN 1999 or in the relevant execution standards, or referenced material or product specifications.
- the structure will be adequately maintained - the structure will be used in accordance with the design assumptions.

EN 1990 and all other Eurocodes make provision for a National Annex whereby the National Standard implementing a Eurocode is permitted to have a choice where the Eurocode allows such a choice in respect of Nationally Determined Parameters (NDPs) for specific procedures or classes or values. The National Annex for IS EN 1990 provides the following in regard to NDPs:

- Table 2.1: Indicative design working life as given in EN 1990 for the five categories of constructions listed with an extension to 120 years for the working life for bridges subject to the requirement and agreement with clients (A1. 1(1)).
- In regard to combinations of actions clauses A1.2.1 (2) and A1.2.1 (3) apply without modification.
- Table A1.1 of clause A1.2.2 which gives combination, frequent and quasi-permanent factors for variable action loading is unchanged for all categories of loaded areas. The eight categories listed are referenced A, B, C, D, E, F, G, and H. The areas referenced are domestic-residential, office, congregational, shopping, storage, traffic ($\leq$ 30 kN) traffic ($>$ 30 kN $<$ 160 kN), and roof areas respectively.
- Design values of actions in persistent and transient situations for ultimate limit states, are given in tables A1.2(A), A1.2(B) and A1.2(C). These tables are required to be implemented nationally. Equation 6.10 shall normally be used. Equations 6.10(a) and 6.10(b), which govern the application of the actions in the tables are included for use subject to approval of a client and/or regulatory authority. No

modification of values applies to Table A1.2 (A), the upper value of 1.15 is chosen in regard to the application of equation 6.10(b) of Table A1.2(B) and no modification is made to the values given in Table A1.2(C).

- Design of structural members comprising geotechnical actions where these need to be considered, may be undertaken by using one of three approaches listed under A1.3.1(5) supplemented for geotechnical actions and resistances by EN 1997 (Eurocode 7: *Geotechnical design*).
- Design values of actions in accidental and seismic design situations as given in Table A1.3, modified to exclude more than one main variable action which may be taken with its frequent value. The seismic design situation is also excluded unless specified by a client.
- The criteria in clause A1.4.2(2) in regard to serviceability as given have not been modified in the National Annex and hence criteria are to be specified for each project and agreed with the particular client.
- Annexes B, C and D, which are informative only, are not subject to any direction in the National Annex.

1.03 Actions on structures (IS EN 1991) - Eurocode 1

EN 1991-1-1 (Eurocode 1) provides design guidance and actions for the structural design of buildings and civil engineering works including data for densities of construction materials and stored materials, self weight of construction elements and imposed loadings for buildings.

EN 1991-1-1 includes provision for a National Annex whereby the National Standard implementing 1991-1-1 is permitted to have a choice where the Eurocode allows such a choice in respect of Nationally Determined Parameters (NDPs). The National Annex for EN 1991-1–l includes the following in respect of NDPs.

- Clause 2.2 (3) - Imposed loads should be taken into account as quasi-static actions (EN 1990, clause 1.5.3.13). Load models may include dynamic effects if there is no risk of resonance or other significant

dynamic response of the structure. If resonance effects from synchronised rhythmical movement of people or dancing or jumping may be expected, the load model should be determined for special dynamic analysis.

- Clause 5.2.3 - Additional provisions specific for bridges is not relevant in respect of this handbook.
- Table 6.1 of clause 6.3.1.1 - Categories of use to be as given in the Eurocode subject to the sub-division of category A (areas for domestic and residential use) as follows:
  - A1: Rooms in houses and dwellings
  - A2: - Rooms in residential buildings
    - Bedrooms and wards in hospitals;
    - Bedrooms in hotels and hostels;
    - Kitchens and toilets.
- Table 6.2 of clause 6.3.1.2 - Values of actions provides a range for imposed loadings in regard to the different categories of loaded areas. The National Annex lists for table 6.2 the recommended values for use in Ireland for imposed loads on floors, balconies and stairs.
- Clause 6.3.1.2 (10) which provides a reduction factor for imposed loads from a single category of loaded areas is to be used in accordance with the requirements of Note 1 of the clause.
- Clause 6.3.1.2 (10) which provides a reduction factor for imposed loads, from several storeys, on columns and walls is to be used in accordance with Note 1 of the clause.

1.04 Eurocode 5 as a structural timber limit state design code

EN 1995-1-1 is a limit state design code which requires structural stability to be in accordance with two specifically defined states, within which the structure complies in relation to particular performance criteria. These limit states are:

- Ultimate limit state — associated with collapse or with other forms of failure which include loss of equilibrium, excessive deformation, transformation into a mechanism, rupture or loss of stability.
- Serviceability limit state — associated with deformation which affects the appearance or effective use of the structure, vibrations which cause discomfort to people or damage to the structure, damage or cracking which is likely to adversely affect the durability of the structure.

The ultimate limit state criteria ensure that the probability of failure is acceptably low and the serviceability limit state criteria ensure satisfactory behaviour under service (working) actions. In special circumstances limit state criteria involving fatigue and fire resistance may require to be considered.

The basic requirements of EN 1990: 2002 section 2 are deemed to be satisfied for timber structures when limit state design, in conjunction with the partial factor method using EN 1990:2002 and EN 1991 for actions and their combinations and EN 1995 for resistances, and its rules for serviceability and durability, are applied. Regulatory authorities in each member state have the right to determine values related to safety from a range of values, classes or symbols.

1.05 Eurocodes recognized for construction works

Member states of the European Union and the European Free Trade Association recognise that Eurocodes are appropriate for the following purposes:

- as a framework for drawing up harmonised technical specifications for construction products.
- as a basis for specifying contracts for the execution of construction works and related engineering services.
- as a means of validifying compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC particularly regarding mechanical resistance and stability.

Section 2: Standards Referenced in Eurocode 5

2.01 Standards grouped in categories

The application of EN 1995-1-1 for design of structural timber and timber structures relies on data provided in numerous CEN standards. Eurocode 5 refers to fifty-three normative standards and a number of these refer to several other EN standards in regard to compliance. The standards which are relevant to this handbook are grouped hereunder into material categories and listed accordingly. Such standards are described in subsequent paragraphs of this section. Since publication of EN 1995-1-1 a number of the standards have been, or are currently being, revised, merged or altered. Where feasible the modifications are given herein for specific standards. The grouping into material categories is for the convenience of use in respect of this handbook and the following are the respective groups:

- Solid timber, glued laminated timber and laminated veneer lumber.
- Wood-based panels.
- Metal fasteners.
- Prefabricated wall floor and roof elements.

2.02 Solid timber, glulam and LVL

Relevant standards for solid timber, glued laminated timber (glulam) and laminated veneer lumber (LVL) are:

- IS EN 336: *Structural timber — permissible size deviations*
- IS EN 338: *Structural timber — strength classes*
- IS EN 385: *Finger jointed structural timber — requirements*
- IS EN 390: *Glued laminated timber — sizes — permissible deviations*
- IS EN 1194: *Glued laminated timber — strength classes*

- IS EN 14080: *Glued laminated timber — requirements*
- IS EN 14081: *Strength graded rectangular cross-section structural timber*
- IS EN 14279: *Laminated veneer lumber — specifications*

2.03 Wood-based panels

Relevant standards for wood-based panels:

- IS EN 300: *Oriented Strand Board (OSB) — Definition, classification and specifications*
- IS EN 312-4: *Particleboards — Specifications - Part 4*
- IS EN 312-5: *Particleboards — Specifications - Part 5*
- IS EN 312-6: *Particleboards — Specifications - Part 6*
- IS EN 312-7: *Particleboards — Specifications - Part 7*
- IS EN 622-2: *Fibreboards — Specifications - Part 2*
- IS EN 622-3: *Fibreboards — Specifications - Part 3*
- IS EN 622-4: *Fibreboards — Specifications - Part 4*
- IS EN 622-5: *Fibreboards — Specifications - Part 5*
- IS EN 636-1: *Plywood — Specifications - Part 1*
- IS EN 636-2: *Plywood — Specifications - Part 2*
- IS EN 636-3: *Plywood — Specifications - Part 3*
- IS EN 12369-1: *Wood-based panels - Part 1*
- IS EN 12369-2: *Wood-based panels - Part 2*
- IS EN 12871: *Wood-based panels — Performance*
- IS EN 13986: *Wood-based panels — Characteristics*
- IS EN 14374: *Structural laminated veneer lumber — requirements*

2.04 Metal fasteners

Relevant standards for metal fasteners for timber elements:

- IS EN 912: *Specifications for connectors for timber*
- IS EN 1380: *Load-bearing nailed joints*
- IS EN 1381: *Load-bearing stapled joints*
- IS EN 1382: *Withdrawal capacity of timber fasteners*
- IS EN 1383: *Pull through testing of timber fasteners*
- IS EN 13271: *Characteristic capacities and slip module for connector joints*
- IS EN 14545: *Connectors - requirements*
- IS EN 14592: *Fasteners - requirements*

2.05 Prefabricated wall floor and roof elements

Relevant standards for prefabricated wall floor and roof elements:

- IS EN 14732-1: *Prefabricated wall floor and roof elements - Part 1*
- IS EN 14732-2: *Prefabricated wall floor and roof elements - Part 2*

2.06 Summarised descriptions of the standards listed in 2.02

The following relates to the information included in the group of standards relevant to solid timber, glued laminated timber and laminated veneer lumber:

- IS EN 336 relates to permissible deviations for sawn timber sizes and is a specification for structural timber produced from coniferous and poplar species. It does not list target sizes but defines such sizes as the desired dimensional values at 20 percent moisture content. It specifies the deviations which are permitted at that moisture content in respect of two tolerance classes, namely class 1 and class 2 as follows:

- Tolerance class 1:

  a) thickness and width ≤ 100 mm : + 3 mm - 1 mm

  b) thickness and width > 100 mm: + 4 mm – 2 mm

- Tolerance class 2:

  a) thickness and width ≤ 100 mm: + 1 mm – 1 mm

  b) thickness and width > 100 mm: + 1.5 mm - 1.5 mm

The standard stipulates that the thickness and width of a piece of sawn timber can be assumed to increase by 0.25 percent for every 1 percent moisture content higher than 20 percent up to 30 percent and decrease by 0.25 percent for every 1 percent moisture content lower than 20 percent. The values are independent of species.

- IS EN 338 provides a strength class system for sawn timber whereby different species can be grouped into categories of strength, depending on the quality of the particular timber piece. In this way the designer specifies a particular strength class which does not require reference to any particular species. A particular species from a particular source or region does not have a uniform strength quality throughout the sawn timber pieces produced from its logs. It is therefore appropriate to grade (visually or machine - preferably by machine) into strength classes which are independent of source and species. Strength classes are designated in a range of C14 (lowest) through twelve classes to C50 (highest) in which the numeral in the class designation represents the characteristic bending strength of the timber. Each strength class with its other characteristic values is listed in table 1 of the standard. Design computations are based on target sizes for thickness and width at moisture content of 20 percent.

Information relevant to seven strength classes and the related characteristic values is given hereunder:

Strength Class:	C14	C16	C18	C20	C22	C24	C27
Bending strength (N/mm^2):	14	16	18	20	22	24	27
Tension parallel (N/mm^2):	8	10	11	12	13	14	16
Compression parallel (N/mm^2):	16	17	18	19	20	21	22
Tension perpendicular (N/mm^2):	0.4	0.5	0.5	0.5	0.5	0.5	0.6
Compression perpendicular (N/mm^2):	2.0	2.2	2.2	2.3	2.4	2.5	2.6
Shear (N/mm^2):	1.7	1.8	2.0	2.2	2.4	2.6	2.8
Mean MoE parallel (kN/mm^2):	7.0	8.0	9.0	9.5	10.0	11.0	11.5
5 percentile MoE parallel (kN/mm^2):	4.7	5.4	6.0	6.4	6.7	7.4	7.6
Mean MoE perpendicular (kN/mm^2):	0.23	0.27	0.30	0.32	0.33	0.37	0.38
Mean shear modulus (kN/mm^2):	0.44	0.50	0.56	0.59	0.63	0.69	0.72
Density - characteristic (kg/m^3):	290	310	320	330	340	350	370
Density - mean (kg/m^3):	350	370	380	390	410	420	450

This standard is currently within the revision process.

- IS EN 385 stipulates the performance requirements and minimum production requirements for finger jointed structural timber. Such timber would be suitable for use in joists, rafters and laminates for glued laminated timber.
- IS EN 390 relates to permissible deviations for glued laminated timber of rectangular cross sections and widths of 50 to 500 mm with depths of 100 to 2500 mm. The glulam member at a reference moisture content of 12 percent is required to have a specified size which is defined as the target size. Where moisture content differs from 12 percent a correction size is to be established by calculation based on the difference between the reference moisture content and the actual moisture content, a moisture deformation factor, and the actual size of a member (width or length) at its actual moisture content. Deviation of width from target size by any corrected size shall not exceed ± 2 mm for all widths. Deviation of depth shall not exceed +4/-2 mm where depth ≤ 400 mm and shall not exceed +1/-0.5 percent where depth > 400 mm. Deviation of length shall not exceed ± 2 mm for length ≤ 2000 mm, nor exceed ± 0.1 percent for length > 2000 mm and ≤ 20 m and shall not be more than ± 20 mm for lengths greater than 20 m. Angles of a cross-section shall deviate from the right angle by not more than 2 percent.

- IS EN 1194 specifies a strength class system for glued laminated timber (glulam). This system permits combinations of grade and species to be classified together with a common set of strength and stiffness properties for each class and results in the introduction of an advantageous economic factor for glulam production. A minimum of four laminations is necessary for the inclusion of a glulam piece in a strength class designation. Laminations consist of sawn timber elements of particular strength class C14 and higher. Laminations are in the form of homogenous (similar strength class throughout) or combined (inner and outer laminations of different strength classes). Where combined laminations are used, the inner ones are of a lower strength class. Strength classes are designated GL24c to GL36h with references 'c' and 'h' indicating combination and homogenous form of lamination lay-up respectively. Strength and stiffness properties for the two types differ in characteristic values except for bending strength, modulus of elasticity parallel to the grain and modulus of elasticity perpendicular to the grain. The values for the differing properties are of the order of 5 to 22 per cent greater for the homogenous lay-up arrangements. Where the overall depth is less than 600 mm a factor greater than unity but not more than 1.1 is applicable to all properties. Where the width is greater than the depth and is also less than 600 mm a similar factor is applicable to the other characteristic values listed in IS EN 1194.

Characteristic strength and stiffness properties are given in the standard in respect of homogenous glulam lay-up for four particular strength classes, designated GL24, GL28, GL32 and GL36. The laminations require to be strength class C24 and higher. Strength and stiffness characteristic values for other glulam strength classes can be derived by calculation using formulae given in the standard together with strength class characteristic values listed in EN 338. Information relevant for seven homogenous glulam strength classes, consisting of the four designated above and three others, for which properties have been derived by calculation and which are referenced GL22, GL20 and GL18 (for each of which laminations are of strength classes lower than C24) is given hereunder:

Strength Class:	18h	20h	22h	24h	28h	32h	36h
Bending strength(N/mm^2):	16.50	19.80	21.45	24	28	32	36
Tension parallel (N/mm^2):	11.50	13.85	15.05	16.5	19.5	22.5	26
Compression/parallel (N/mm^2):	16.85	20.20	21.90	24	26.5	29	31
Tension perpendicular (N/mm^2):	0.30	0.35	0.40	0.40	0.45	0.50	0.60
Compression perpendicular (N/mm^2):	1.85	2.25	2.45	2.70	3.00	3.30	3.60
Shear strength (N/mm^2):	1.20	1.40	1.55	2.70	3.20	3.80	4.30
MoE parallel (mean) (N/mm^2):	9450	9975	10550	11600	12600	13700	14700
MoE parallel (5 percentile) (N/mm^2):	7650	8075	8500	9400	10200	11100	11900
MoE perpendicular (mean) (N/mm^2):	315	330	350	390	420	460	490
MoE shear (mean) (N/mm^2):	585	615	650	720	780	850	910
Density-characteristic (kg/m^3):	350	360	375	380	410	430	450

Requirements in respect of characteristic strength and stiffness properties are also listed in the standard for combined lay-up glulam in respect of strenght class designations GL24, GL28, GL32 and GL36. The basis for computation of element analysis for this lay-up form of glulam was not considered to be adequately reliable during the preparation of this handbook. Hence the relevant strength and stiffness characteristic values tabulation is not included herein.

This standard is currently within the revision process.

- IS EN 14080 specifies the requirements for glued laminated timber for use in load-bearing structures. It includes the requirements for large finger joints and for production from untreated timber as well as timber treated against biological attack. The standard includes requirements on performance, verification on characteristic values, bonding strength of joints, durability against biological attack, formaldehyde emission, evaluation of conformity, marking, test procedure and information on compliance in respect of the EU Construction Products Directive.
- IS EN 14081-1 is in respect of structural rectangular cross-section timber. It provides the requirements for strength grading sawn or planed timber visually or by machine, having deviations from target sizes as stipulated in IS EN 336. It does not include finger jointed timber in the requirements. It sets out requirements for factory production control, marking and information on compliance in

respect of EU Construction Products Directive. There are three other parts to the standard as follows:

- IS EN 14081-2: Part 2: *Machine Grading - Additional requirements for initial type testing*
- IS EN 14081-3: Part 3: *Machine Grading - Additional requirements for factory production control*
- IS EN 14081-4: Part 4: *Machine Grading - Machine settings for machine controlled systems*

- IS EN 14279: *Laminated veneer lumber (LVL) - Specifications, definitions, classification and requirements:* This standard relates to the use of LVL in the context of wood-based panels.

2.07 Summarised descriptions of the standards listed in 2.03

The following relates to the information included in the group of standards relevant to wood-based panels and laminated veneer lumber (LVL):

- Standard IS EN 300 provides definitions, classifications and specifications for oriented strand boards (OSB). The following data are relevant to the use of OSB in regard to load-bearing wood-based panels.
  - boards for use in dry conditions are required to have the characteristics appropriate for use under service class 1 conditions defined in EN 1995-1-1. Boards for use in humid conditions are required to have the characteristics appropriate for use under service class 2 conditions defined in EN 1995-1-1.
  - boards are classified in four types, namely, OSB/1, OSB/2, OSB/3 and OSB/4. OSB/2 type is for use as load-bearing boards in dry conditions, OSB/3 type is for use as load-bearing boards in humid conditions and OSB/4 type is for use as heavy duty load-bearing boards in humid conditions.

- general requirements for all OSB type boards are given in table 1 of the standard and include tolerances on nominal dimensions, tolerance on edge straightness, tolerances on squareness, moisture content, tolerance on the mean density within a board and formaldehyde emission data.
- requirements for load-bearing boards for use in dry conditions, in addition to those given in table 1, include data for bending strengths, moduluse of elasticity in bending, internal bond and swelling in thickness and are listed in table 3.
- requirements for load-bearing for use in humid conditions in addition to those given in table 1, include data for bending strengths, modulus of elasticity in bending, internal bond and swelling in thickness, and are listed in table 4.
- requirements for heavy duty load-bearing boards for use in humid conditions in addition to those given in table 1, include data for bending strengths, modulus of elasticity in bending, internal bond and swelling in thickness, and are listed in table 6. A comparison of particular properties in respect of the three categories of load-bearing boards given in tables 3, 4 and 6 is as follows:

Type OSB/2

Thickness range (mm):	6 to 10	11 to 17	18 to 25
Bending strength (N/mm^2):			
- major axis:	22	20	18
- minor axis:	11	10	9
MoE in bending (N/mm^2):			
- major axis:	3500	3500	3500
- minor axis:	1400	1400	1400
Internal bond (N/mm^2):	0.34	0.32	0.30
Swelling in thickness (24h):	20%	20%	20%

Type OSB/3

Thickness range (mm):	6 to l0	11 to 17	18 to 25
Bending strength (N/mm^2):			
- major axis	22	20	18
- minor axis:	11	10	9
MoE in bending (N/mm^2):			
- major axis:	3500	3500	3500
- minor axis:	1400	1400	1400
Internal bond (N/mm^2):	0.34	0.32	0.30
Swelling in thickness (24h):	15%	15%	15%

Type OSB/4

Thickness range (mm):	6 to 10	11 to 18	19 to 25
Bending strength (N/mm^2):			
- major axis:	30	28	26
- minor axis:	16	15	14
MoE in bending (N/mm^2):			
- major axis:	4800	4800	4800
- minor axis:	1900	1900	1900
Internal bond (N/mm^2):	0.50	0.45	0.40
Swelling in thickness (24h):	12%	12%	12%

The values listed relate to product properties but are not characteristic values for use in design calculations. Characteristic values are given in IS EN 1058.

- IS EN 312: 2003 provides specifications for particleboards. It supersedes IS EN 312 - Part 1, 2, 3, 4, 5, 6 and 7 which have been combined and contains modifications made in the contents of the separate parts during the preparation of the standard. The following data are relevant to the use of particleboards in regard to load-bearing wood-based panels:
    - boards are classified into seven types, namely, P1, P2, P3, P4, P5, P6 and P7. Type P4 is for use as load-bearing board in dry conditions, P5 type is for use as load-bearing board in humid conditions, P6 type is for use as heavy duty load-bearing board in dry conditions and P7 type is for use as heavy duty load-bearing board in humid conditions.

- general requirements for all boards are given in table 1 and include data for tolerances on nominal dimensions, edge straightness, squareness, moisture content, tolerance on the mean density within a board and formaldehyde data.
- requirements for load-bearing board for use in dry conditions (P4 type) in addition to those given in table 1, include data for bending strengths, modulus of elasticity in bending, internal bond and swelling in thickness and are listed in table 6. There are eight thickness ranges for these boards from 3 – 4 mm (nominal) to 32 – 40 mm and greater than 40 mm. The corresponding bending strength range is 15 – 17 N/mm^2, with a modulus of elasticity in bending from 1950 – 1200 N/mm^2, internal bond range of 0.45 - 0.20 N/mm^2 and swelling in thickness range over 24 hours of 23% to 14%.
- requirements for load-bearing boards for use in humid conditions (P5 type) in addition to those given in table 1, include properties corresponding to those for P4 type boards for a similar range of thicknesses, a bending strength value range of 20 – 9 N/mm^2, with modulus of elasticity in bending range of 2550 – 1550 N/mm^2, an internal bond range of 0.50 - 0.25 N/mm^2 and swelling in thickness range over 24 hours of 13% to 9%.
- requirements for heavy duty load-bearing boards for use in dry conditions (P6 type) in addition to those given in table 1, include properties corresponding to those for P4 type boards for a similar range of thicknesses, a bending strength value range of 20 – 12 N/mm^2, with modulus of elasticity in bending range of 3150 – 2050 N/mm^2, an internal bond range of 0.60 - 0.25 N/mm^2 and swelling in thickness range over 24 hours of 15% to 13%.
- requirements for heavy duty load-bearing boards for use in humid conditions (P7 type) in addition to those given in table 1, include properties corresponding to those for P4 type boards for a similar range of thicknesses, a bending strength value range of 22 – 15 N/mm^2, with modulus of elasticity in bending range of 3350 – 2400 N/mm^2, an internal bond range of 0.75 - 0.50 N/mm^2 and swelling in thickness range over 24 hours of 9% to 7%.

The values listed relate to product properties and are not characteristic values for use in design calculations. The characteristic values (for use in EN 1995-1-1) are given in IS EN 12369-1 or derived by testing in accordance with particular standards.

- IS EN 622-1: 2003 provides specifications for properties which are common in all uncoated fibreboards and includes in normative references standards IS EN 622-2, IS EN 622-3, IS EN 622-4 and IS EN 622-5, each of which is specifically relevant to hardboards, medium boards, soft boards and medium density boards (MDF) respectively. The standard includes tables 1 and 2 which provide general requirements and tolerances on nominal thicknesses for the different categories of fibreboard. Annex A which is normative indicates a colour coding system which is used to define the panel for use for general purpose or for load-bearing application and also identifies the panel as being suitable for use either in dry, in humid or in exterior conditions.
- IS EN 622-2: 2004: provides specifications for properties and requirements for hardboards in addition to the requirements of IS EN 622-1: 2003.
- IS EN 622-3: 2004 provides specifications for properties and other requirements for medium boards. In addition to the requirements of IS EN 622-1: 2003, requirements for load-bearing boards for use in dry conditions (MBH.LA1) are listed in table 5 for two thickness categories, namely less than 10 mm and greater than 10 mm. The values for properties in respect of these two categories include bending strengths 18 and15 N/mm^2, modulus of elasticity in bending of 1800 and 1600 N/mm^2, internal bond values of 0.10 N/mm^2 for each category of thickness and swelling in thickness over 24 hours of 15% for the two thickness categories. Requirements for heavy duty load-bearing boards in dry conditions (MBH.LA2) in regard to the corresponding properties for the two category thicknesses are listed in table 6 and include bending strengths of 21 and 18 N/mm^2, modulus of elasticity in bending of 2500 and 2300 N/mm^2, internal bond value for each thickness of 0.20 N/mm^2, and swelling in thickness over 24 hours of 15% for each thickness. Where load-

bearing boards are for use in humid conditions (MBH.HLS1) table 7 includes the following requirements in respect of the two categories of thickness and are listed as 20 and 18 N/mm^2 for bending strength, 2000 and 1800 N/mm^2 for modulus of elasticity in bending, 0.30 N/mm^2 internal bond value for both thicknesses and swelling in thickness over 24 hours of 9% for each thickness category. For heavy duty load-bearing boards for use in humid conditions (MBH.HLS2) table 8 of the standard includes the following requirements in respect of the two categories of thickness. The listed values are 28 and 25 N/mm^2 for bending strength, 2900 and 2800 N/mm^2 for modulus of elasticity in bending, 0.20 N/mm^2 internal bond value for both categories and 9% for swelling in thickness over 24 hours for the two categories of thickness.

- IS EN 622-4: 1997 - *Requirements for softboards* clause 3.5 (1) of EN 1995-1-1 significantly restricts the use of softboards specified in this standard. This material in respect of structural works is not included in this handbook. The standard is currently within the revision process.

- IS EN 622-5: 1997: *Requirements for dry process boards (MDF)*. This standard provides specifications for properties and requirements in respect of use for load-bearing boards in dry conditions (MDF.LA). In addition to the requirements of IS EN 622-1: 2003, table 4 of the standard for nominal thickness range 1.8 to greater than 45 mm in nine categories specifies particular properties including values for bending strength range 29 to 19 N/mm^2, modulus of elasticity in bending range of 3000 to 1900 N/mm^2, internal bond values range 0.70 to 0.50 N/mm^2 and swelling in thickness over 24 hours range 45% to 6%. Table 5 lists the corresponding requirements for load-bearing boards for use in humid conditions (MDF.H2S). These include for a corresponding range of nominal thicknesses bending strength range 34 to 19 N/mm^2, modulus of elasticity in bending range 3000 to 2200 N/mm^2 internal bond range 0.70 to 0.60 N/mm^2 and swelling in thickness over 24 hours range of 35% to 6%. Options are also included in regard to swelling in thickness values after cyclic testing, and in regard to internal bond values following

cyclic testing and boil test in accordance with EN 1087. This standard is currently within the revision process.

- IS EN 636:2003 supersedes EN 636-1, EN 636-2 and EN 636-3 which are normative references in IS EN 1995-1-1, in respect of plywood specifications. The new standard includes modifications which gives a classification system for bending strength, bending modulus and formaldehyde release (in accordance with IS EN 13986). Annex A of the standard is normative, it consists of Table A.1 which provides information on physical properties, mechanical properties, performance properties and other properties. The information provided is in respect of dimensional changes, moisture content, density, tension properties, shear properties, compression properties and resistance to withdrawal of fasteners. In respect of performance properties references are given for flooring, floating floors, walling, roofing and duration of load creep factors.

The standard provides a classification system under clause 4 whereby tables 1 and 2 provide values corresponding to characteristic values for structural uses for all types of plywood independent of composition factors (species, number of plies, thickness of plies). The values correspond to 5 percentile values based on the mean values and determined in accordance with the requirements of IS EN 310 and IS EN 326-2. These values are designated bending strength classes ($f_{m0.5}$) of F3, F5, F10, F15, F20, F25, F30, F40, F50, F60, F70 and F80 for lower limit values of 5, 8, 15, 23, 30, 38, 45, 60, 75, 90, 105 and 120 N/mm^2 respectively. The second table provides bending modulus classes ($E_{m0.5}$) of E5, EI0, E15, E20, E25, E30, E40, E50, E60, E70, E80, E100, E120 and E140 for lower limit values respectively of 500, 1000, 2000, 2500, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10,000, 12,000 and 14,000 N/mm^2. A designation form for a particular plywood quality is given based on four references, namely, strength in length direction/strength in width direction/modulus in length direction/modulus in width direction. Where these characteristics for bending and moduli values are f_{mo} = 22 N/mm^2, f_{m90} = 39 N/mm^2, E_{mo} = 3800 N/mm^2 and E_{m90} = 4200 N/mm^2 the designation would be F_{10}/F_{20} E_{30}/E_{40}. The values given in tables 1 and 2 are for use in relation to compliance with IS EN 636 as part of the

quality control procedure in that standard. Such values shall not be used in structural design and reference should be made to IS EN 12369-2 for the required characteristic values.

The 5 percentile values for bending strength and bending modulus are required to be not less than the lower limit values given in tables 1 and 2 for designation into the classification system of clause 4 of this standard. The characteristic values of the mechanical properties shall be determined in accordance with IS EN 1058 from IS EN 789 test results. Tabulated minimum characteristic values for mechanical properties of a number of classes are given in IS EN 12369-2. Bending property values are to be used to identify the plywood quality in accordance with IS EN 1072.

- Standard IS EN 12369-1: 2001: *Wood-based panels - characteristic values for structural design - Part 1: OSB, particleboards and fibreboards*. The characteristic values for mechanical properties and density are included for OSB/2, OSB/3 and OSB/4, for particleboard P4, P5, P6 and P7, for hardboard HB.HLA2, for medium board MBH.1A2 and for MDF.LA and MDF.HLS. The characteristic values given in this standard are the minimum values applicable to products conforming to the appropriate EN specification standards. Tables 2 and 3 indicate the minimum required characteristic values for density, strength and stiffness properties for the particular three ranges of thicknesses referenced in IS EN 300, in respect of OSB/2, OSB/3 and OSB/4. The values for each of the three load-bearing type boards are:

Type OSB/2

Thickness (mm):	6 to 10	11 to 17	18 to 25	
Density (kg/m^3):	500	500	500	(Mean)
Bending strength (N/mm^2):	18.0	16.4	14.8	(0)
	9.0	8.2	7.4	(90)
Tension strength (N/mm^2):	9.9	9.4	9.0	(0)
	7.2	7.0	6.8	(90)
Compression strength (N/mm^2):	15.9	15.4	14.8	(0)
	12.9	12.7	12.4	(90)
Panel shear (N/mm^2):	6.8	6.8	6.8	
Planar shear (N/mm^2):	1.0	1.0	1.0	
Modulus of E (bending) (N/mm^2):	4930	4930	4930	(0)
	1980	1980	1980	(90)
Modulus of E (tension) (N/mm^2):	3800	3800	3800	(0)
	3000	3000	3000	(90)
Modulus of E (compression) (N/mm^2):	3800	3800	3800	(0)
	3000	3000	3000	(90)
Panel shear (modulus) (N/mm^2):	1080	1080	1080	
Planar shear (modulus) (N/mm^2):	50	50	50	

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.85 of the mean stiffness values tabulated above.

Type OSB/3:

Table 2 values (listed above) for density, strength and stiffness for minimum characteristic properties also apply to OSB/3 type. The product properties of OSB/2 and OSB/3 specified in IS EN 300 are also identical expect in respect of the values for swelling in thickness over 24 hours which is given as 20% and 15% respectively in respect of all ranges of thickness.

Note: Product properties (as in IS EN 300) are material identification specifications and are not values for use in design calculations.

Characteristic values as listed in IS EN 12369-1 shall be used in design calculations.

Type OSB/4:

Table 3 indicates the minimum required characteristic values of the mechanical properties and density which are required to be applied in structural design calculations for the particular three ranges of thicknesses referenced. These characteristic values are:

Thickness (mm):	<6 to10	11 to 17	18 to 25	
Density (kg/mm^3):	550	550	550	
Bending strength (N/mm^2):	24.5	23.0	21.0	(0)
	13.0	12.2	11.4	(90)
Tension strength (N/mm^2):	11.9	11.4	10.9	(0)
	8.5	8.2	8.0	(90)
Compression strength (N/mm^2):	18.1	17.6	17.0	(0)
	14.3	14.0	13.7	(90)
Panel shear (N/mm^2):	6.9	6.9	6.9	
Planar shear (N/mm^2):	1.1	1.1	1.1	
Modulus of E (bending) (N/mm^2):	6780	6780	6780	(0)
	2680	2680	2680	(90)
Modulus of E (tension) (N/mm^2):	4300	4300	4300	(0)
	3200	3200	3200	(90)
Modulus of E (compression) (N/mm^2):	4300	4300	4300	
	3200	3200	3200	
Panel shear (modulus) (N/mm^2):	1090	1090	1090	
Planar shear (modulus) (N/mm^2):	60	60	60	

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.85 of the mean stiffness values tabulated above.

The standard provides in Tables 4, 5, 6 and 7 the required minimum characteristic values of the mechanical properties and density for particleboards referenced P4, P5, P6 and P7 respectively which comply with IS EN 312:2003. The minimum characteristic values are provided in respect of six ranges of board thickness and the tabulated data are listed as follows:

Particleboard P4

Thickness (mm):	<6 to 13	>13 to 20	>20 to 25
Density (kg/m^3):	650	600	550
Bending (N/mm^2):	14.2	12.5	10
Tension (N/mm^2):	8.9	7.9	6.9
Compression (N/mm^2):	12.0	11.l	9.6
Panel shear (N/mm^2):	6.6	6.1	5.5
Planar shear (N/mm^2):	1.8	1.6	1.4
MoE (bending) (N/mm^2):	3200	2900	2700
MoE (tension) (N/mm^2):	1800	1700	1600
MoE (compression) (N/mm^2):	1800	1700	1600
MoE (panel shear) (N/mm^2):	860	830	770

Thickness (mm):	26 to 32	33 to 40	>40
Density (kg/m^3):	550	500	500
Bending (N/mm^2):	9.2	7.5	5.8
Tension (N/mm^2):	6.1	5.0	4.4
Compression (N/mm^2):	9.0	7.6	6.1
Panel shear (N/mm^2):	4.8	4.4	4.2
Planar shear (N/mm^2):	1.2	1.1	1.0
MoE (bending) (N/mm^2):	2400	2100	1800
MoE (tension) (N/mm^2):	1400	1200	1100
MoE (compression) (N/mm^2):	1400	1200	1100
MoE (panel shear) (N/mm^2):	680	600	550

The 5 percentile values for stiffness should be taken as 0.8 times the mean values given in table 4. Other properties which are not given in table 4 shall comply with the requirements given in IS EN 312: 2003.

The minimum characteristic values for P5 category particleboard are as set out in table 5 and are as follows:

Particleboard P5

Thickness (mm):	>6 to 13	14 to 20	21 to 25
Density (kg/m^3):	650	600	550
Bending (N/mm^2):	15.0	13.3	11.7
Tension (N/mm^2):	9.4	8.5	7.4
Compression (N/mm^2):	12.7	11.8	10.3
Panel shear (N/mm^2):	7.0	6.5	5.9
Planar shear (N/mm^2):	1.9	1.7	1.5
MoE (bending) (N/mm^2):	3500	3300	3000
MoE (tension) (N/mm^2):	2000	1900	1800
MoE (compression) (N/mm^2):	2000	1900	1800
MoE (panel shear) (N/mm^2):	960	930	860

Thickness (mm):	26 to 32	33 to 40	>40
Density (kg/m^3):	550	500	500
Bending (N/mm^2):	10.0	8.3	7.5
Tension (N/mm^2):	6.6	5.6	5.6
Compression (N/mm^2):	9.8	8.5	7.8
Panel shear (N/mm^2):	5.2	4.8	4.4
Planar shear (N/mm^2):	1.3	1.2	1.0
MoE (bending) (N/mm^2):	2600	2400	2100
MoE (tension) (N/mm^2):	1500	1400	1300
MoE (compression) (N/mm^2):	1500	1400	1300
MoE (panel shear) (N/mm^2):	750	690	660

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.80 of the mean stiffness values tabulated above. Other properties not given in table 5 shall comply with the requirements of IS EN 312. 2003 for P5 type particleboard.

The minimum required characteristic values for P6 category particleboard are set out in table 6 of the standard and are as follows:

Particleboard P6

Thickness (mm):	>6 to 13	14 to 20	21 to 25
Density (kg/m^3):	650	600	550
Bending (N/mm^2):	16.5	15.0	13.3
Tension (N/mm^2):	10.5	9.5	8.5
Compression (N/mm^2):	14.1	13.3	12.8
Panel shear (N/mm^2):	7.8	7.3	6.8
Planar shear (N/mm^2):	1.9	1.7	1.7
MoE (bending) (N/mm^2):	4400	4100	3500
MoE (tension) (N/mm^2):	2500	2400	2100
MoE (compression) (N/mm^2):	2500	2400	2100
MoE (panel shear) (N/mm^2):	1200	1150	1050

Thickness (mm):	26 to 32	33 to 40	>40
Density (kg/m^3):	550	500	500
Bending (N/mm^2):	12.5	11.7	10.0
Tension (N/mm^2):	8.3	7.8	7.5
Compression (N/mm^2):	12.2	11.9	10.4
Panel shear (N/mm^2):	6.5	6.0	5.5
Planar shear (N/mm^2):	1.7	1.7	1.7
MoE (bending) (N/mm^2):	3300	3100	2800
MoE (tension) (N/mm^2):	1900	1800	1700
MoE (compression) (N/mm^2):	1900	1800	1700
MoE (panel shear) (N/mm^2):	950	900	880

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.80 of the mean stiffness values tabulated above. Other properties not given in table 5 shall comply with the requirements of EN 312. 2003 for P6 type particleboard.

The minimum required characteristic values for P7 type particleboard (heavy duty load-bearing boards for use in humid conditions) are set out in table 7 of the Standard and are as follows:

Particleboard P7

Thickness (mm):	>6 to 13	14 to 20	21 to 25
Density (kg/m^3):	650	600	550
Bending (N/mm^2):	18.3	16.7	15.4
Tension (N/mm^2):	11.5	10.6	9.8
Compression (N/mm^2):	15.5	14.7	13.7
Panel shear (N/mm^2):	8.6	8.1	7.9
Planar shear (N/mm^2):	2.4	2.2	2.0
MoE (bending) (N/mm^2):	4600	4200	4000
MoE (tension) (N/mm^2):	2600	2500	2400
MoE (compression) (N/mm^2):	2600	2500	2400
MoE (panel shear) (N/mm^2):	1250	1200	1150

Thickness (mm):	26 to 32	33 to 40	>40
Density (kg/m^3):	550	500	500
Bending (N/mm^2):	14.2	13.3	12.5
Tension (N/mm^2):	9.4	9.0	8.0
Compression (N/mm^2):	13.5	13.2	13.0
Panel shear (N/mm^2):	7.4	7.2	7.0
Planar shear (N/mm^2):	1.9	1.9	1.8
MoE (bending) (N/mm^2):	3900	3500	3200
MoE (tension) (N/mm^2):	2300	2100	2000
MoE (compression) (N/mm^2):	2300	2100	2000
MoE (panel shear) (N/mm^2):	1100	1050	1000

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.80 of the mean stiffness values tabulated above. Other properties not given in table 5 shall comply with the requirements of EN 312. 2003 for P7 type particleboard.

The standard provides in tables 8, 9, 10 and 11 data in respect of fibreboards which are used structurally and specified in product specification IS EN 622-2-3 and 5.

The data provided include required minimum characteristic values of mechanical properties and densities for hardboards type HB. HLA2 to IS EN 622-2, medium boards type MBH. LA2 to IS EN 622-3, medium density fibreboards (MDF) to IS EN 622-5. The standard stipulates the following in regard to minimum characteristic values for the particular

fibreboard types when used structurally under particular service conditions:

Fibreboard type HB. HLA2 hardboard: Table 8.

Thickness (mm):	≤3.5	>3.5 - 5.5	>5.5
Density (kg/m^3):	900	850	800
Bending (N/mm^2):	37	35	32
Tension (N/mm^2):	27	26	23
Compression (N/mm^2):	28	27	24
Panel shear (N/mm^2):	19	18	16
Planar shear (N/mm^2):	3	3	2.5
MoE (bending) (N/mm^2):	5000	4800	4600
MoE (tension) (N/mm^2):	5000	4800	4600
MoE (compression) (N/mm^2):	5000	4800	4600
MoE (panel shear) (N/mm^2):	2100	2000	1900

Note: The 5% characteristic values for stiffness should be taken as 0.80 times the mean values given in table 8. Other properties not given in table 8 shall comply with the requirements given in IS EN 622-2 for HB. HLA2.

Fibreboard type MBH.LA2 medium boards: Table 9.

Thickness (mm):	≤10	>10
Density (kg/m^3):	650	600
Bending (N/mm^2):	17	15
Tension (N/mm^2):	9	8
Compression (N/mm^2):	9	8
Panel shear (N/mm^2):	5.5	4.5
Planar shear (N/mm^2):	0.3	0.25
MoE (bending) (N/mm^2):	3100	2900
MoE (tension) (N/mm^2):	3100	2900
MoE (compression) (N/mm^2):	3100	2900
MoE (panel shear) (N/mm^2):	1300	1200

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.80 of the mean stiffness values tabulated above. Other properties not given in table 9 shall comply with the requirements given in IS EN 622.3 for MBH.LA2. These characteristic values have been calculated from product specification standards using derived conversion factors.

Fibreboard type MDF. LA: Table 10.

Thickness (mm):	>1.8 to 12	>12 to 19	>19 to 30	>30
Density (kg/m^3):	650	600	550	500
Bending (N/mm^2):	21	21	21	21
Tension (N/mm^2):	13.0	12.5	12.0	l0.0
Compression (N/mm^2):	13.0	12.5	12.0	l0.0
Panel shear (N/mm^2):	6.5	6.5	6.5	5.0
Planar shear (N/mm^2):	3700	3000	2900	2700
MoE (bending) (N/mm^2):	2900	2700	2000	1600
MoE (tension) (N/mm^2):	2900	2700	2000	1600
MoE (compression) (N/mm^2):	2900	2700	2000	1600
MoE (panel shear) (N/mm^2):	800	800	800	600

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.85 of the mean stiffness values tabulated above. Other properties not given in table 10 shall comply with the requirements given in IS EN 622-5 for MDF. LA.

Fibreboard type MDF .HLS Table 11.

Thickness (mm):	>1.8 to 12	13 to 19	20 to 30	>30
Density (kg/m^3):	650	600	550	500
Bending (N/mm^2):	22	22	21	18
Tension (N/mm^2):	18.0	16.5	16.0	13.0
Compression (N/mm^2):	18.0	16.5	16.0	13.0
Panel shear (N/mm^2):	8.5	8.5	8.5	7.0
MoE (bending) (N/mm^2):	3700	3200	3100	2800
MoE (tension) (N/mm^2):	3100	2800	2700	2400
MoE (compression) (N/mm^2):	3100	2800	2700	2400
MoE (panel shear) (N/mm^2):	1000	1000	1000	800

Note: The 5 percentile characteristic values for stiffness should be calculated as 0.85 of the mean stiffness values tabulated above. Other properties not given in table 11 shall comply with the requirements given in IS EN 622-5 for MDF. HLS.

- IS EN 12369-2: 2004: *Wood-based panels - characteristic values for structural design* - Part 2: *Plywood* includes the characteristic values of the mechanical properties for plywood complying with IS EN 636 and the requirements of IS EN 13986 when used in a bending mode. Plywood load-bearing panels when used structurally under service

class 1 are required under the conditions of this standard to have the class designations of F3 to F80 listed with specified characteristic strengths in bending (f_{mk}) of 3 N/mm^2 to 80 N/mm^2 respectively as set out in table 2 of the standard and to have the class designations of E5 to E140 also listed with specific characteristic mean bending modulus (E_m) of 500 N/mm^2 to 14,000 N/mm^2 respectively as set out in table 3. Plywood of these classes can also be used under service classes 2 and 3 in accordance with the requirements of EN 1995-1-1. The 5 percentile characteristic values for bending modulus should be taken as 80 percent of the mean value given in table 3.

The determination of tensile and compressive characteristic values of a selected plywood of known class can be ascertained from the known bending strength and modulus of that class by use of the calculation method given in IS EN 14272 through use of relevant parameters. Conservative characteristic values for panel and planar shear for all plywoods which have a characteristic density greater than 300 kg/m^3 are given in the standard (IS EN 12369-2). A strength value of 3 N/mm^2 for panel shear and 300 N/mm^2 for modulus of rigidity are listed. The corresponding values for planar shear are 0.5 N/mm^2 and 20 N/mm^2 for strength and stiffness respectively.

- Standard IS EN 12871 : 2001: *Wood-based panels - performance specifications and requirements for load-bearing boards for use in floors walls and roofs*, sets out the performance specifications and requirements for load-bearing wood-based panels used as structural decking and sheathing in floors, roofs and walls and provides a method for demonstrating compliance based on testing. The method for design of the structure by prototype testing is chosen to satisfy the requirements for both impact and concentrated loading. This approach differs to design by calculation using structural characteristic values (as given in IS EN 12369-1 and IS EN 12369-2) or resulting from testing in accordance with IS EN 1058 and IS EN 789. The standard states that the approach chosen provides a more optimised design (reference has not been ascertained showing confirmation). The approach chosen (prototype testing) provides results and output which apply only to one specific structure and as a consequence would have implications for economic production as

well as for structural design. The requirements of the standard have not been applied in regard to designs and computations undertaken in the preparation of this handbook. The standard does provide reference in its Annex B (informative) to IS EN 12872, which gives guidance on installation of load-bearing boards in floors, walls and roofs.

- Standard IS EN 13986: 2002: *Wood-based panels for use in construction - characteristics, evaluation of conformity and marking* is a normative reference in IS EN 1995-1-1. This standard defines wood-based panels for use in construction and specifies the relevant characteristics and the appropriate test methods to determine these characteristics. Data references in respect of solid wood panels, LVL, plywood, OSB, particleboards, fibreboards including medium density fibreboards (MDF) are given. There are fifty-three normative references including one for IS EN 1995-1-1 (Eurocode 5). Terms and definitions for each of the panel types are listed. Performance characteristics for the wood-based panels defined are referenced in tables 1, 2 and 3 for use as structural components through the listing of the performance characteristic for the panel type with the particular clause number where the information is given. The clause references indicate for a particular characteristic (e.g. bending strength) the relevant EN standard(s) in which further information on the characteristic can be found. Table 1 relates to internal use in dry conditions, table 2 to internal use in humid conditions and table 3 to external use. Table 7 relates to internal use as structural floor and roof decking on joists as well as structural wall sheathing on studs. The requirements of IS EN 14732-1 and IS EN 14732-2 are relevant and are considered in sub-section 2.09. Annex A provides standard specification references for the different technical classes of panel, Annex B sets out data concerning formaldehyde classes and Annex ZA provides the relevant information on essential requirements of EU Directives. It also sets out the relevant data concerning CE marking of the different panel types.
- IS EN 14374: *Structural laminated veneer lumber - Requirements*: This standard specifies the requirements for laminated veneer lumber (LVL) for structural applications. It references twelve normative

standards including IS EN 14279 and IS EN 14358 (Structural timber - calculation of characteristic 5-percentile value). It requires a minimum of five number veneers in the cross section of an element, provides data on testing in respect of bonding quality in normative Annex B and sets out the requirements for strength characteristics in bending (edgewise and flatwise), tension (parallel and perpendicular), compression (parallel and perpendicular) and shear for edgewise and flatwise bending. The stipulations regarding moduli of elasticity (parallel and perpendicular), shear moduli relative to bending (edgewise and flatwise), density, moisture content, reaction to fire, formaldehyde release and natural durability are also listed. Evaluation of conformity, sampling, factory production control and marking requirements are specified. Orientation of strength of laminated veneer lumber is set out in informative Annex A, formaldehyde classes are given in normative Annex C and normative Annex Z indicates the clauses of the standard needed for satisfying the EU Construction Products Directive (89/106/EEC) and provides in Section Z.3 CE marking data including figure Z.1 (example CE marking information on the product) and figure Z.2 (example CE marking information in accompanying commercial documents).

2.08 Summarised descriptions of the standards listed in 2.04

The following relate to the information included in the group of standards relevant to metal fasteners for timber elements:

- IS EN 912: - *Specifications for connectors for timber. Timber fasteners - specifications for connectors for timber* was approved by CEN on 21 August 1999. A corrigendum was issued on 11 October 2000. The original standard was required to be given national standard status not later than March 2000 and conflicting national standards were required to be withdrawn not later than March 2000. It includes ten normative references including IS EN 13271 in respect of timber fasteners which provides values for characteristic load-bearing capacities and slip moduli for connector joints. The standard

also includes data on definitions, classification of connectors, type specifications, marking and four normative annexes. These annexes provide the specification details for:

- ring connectors (types A1 - A6) in Annex A
- plate connectors (types Bl - B4) in Annex B
- toothed plate connectors (type C1 – C11) in Annex C
- other connectors (type D1) - Annex D

The corrigendum required the following modifications:

- a change in tolerances of ± 0.2 to ± 0.5 mm for all dimensions given in table A.l
- footnote 1) in regard to tolerances in table A.5 to be deleted and tolerances on all dimensions to be ± 0.5 mm
- a change in tolerances from ± to ± 0.5 mm in table B.l
- a change in tolerances for thickness (t) from ± 0.2 mm to the values given in IS EN 10131 with other dimensions having change in tolerances from ± 0.5 to ± 0.8 mm in respect of table C.l
- tolerances for thickness (t) to be changed from ± 0.2 mm to that given in IS EN 10131 and for other dimensions from 0.5 to 0.8 mm in table C.5.
- for table C.10 the tolerances for all dimensions of ± 0.3 mm to be changed to ± 0.8 mm except for thickness where the height of the toothed plate connector is symmetrical on each side of the central plate which has thickness (t) and which is changed from ± 0.3 to ± 0.5 mm
- for table C.11 the tolerances for all dimensions of ± 0.3 mm to be changed to ± 0.8 mm except for thickness (t), radius (r) and upstand of plate lip (h_1) where the height (h_c) is for a single sided connector, all of which to be changed from ± 0.3 to ± 0.5 mm tolerances.

• IS EN 1380: *Test methods: Load-bearing nails, screws, dowels and bolts* supersedes the 1999 version, which considered only

connections with nails. The scope of the standard was expanded to include screws, dowels and bolts when the product standard for dowel type fasteners IS EN 14592 became available in 2003. It specifies test methods for determining the strength and deformation characteristics of laterally loaded connections with nails, screws, dowels and bolts in load-bearing timber structures. There are ten normative references to other standards. Stipulation is given in respect of conditioning, test piece fabrication and preparation, and also the test procedure. Examples are given of connection details and loading form in respect of particular lateral joint loading. The standard is currently within the revision process.

- IS EN 1381: *Test methods: Load-bearing stapled joints* specifies test methods for determining the strength and deformation characteristics of stapled joints in load-bearing timber structures. The methods assess joints with members of timber (solid timber or glued laminated timber) or wood-based products in the combination proposed for use in service using all types of staples up to 3 mm diameter for circular cross-section staples or 4 x 2 mm for rectangular or oval cross-section staples. Requirements are given for conditioning, fabrication and preparation of test pieces and also the test procedure. Details are given in respect of joint formation for shear tests in tension and compression. Test results are to be determined in accordance with IS EN 26891. The standard is currently within the revision process.
- IS EN 1382: 2000 *Test methods: Withdrawal capacity of timber fasteners* specifies the method for determining withdrawal capacity for all types of nails, screws and staples. Specification is given for conditioning, fabrication and preparation of test pieces and also the test procedures for the fastener axis perpendicular to the grain and parallel to the grain respectively. Test results involve determining the withdrawal parameter from prescribed equations. The standard is currently within the revision process.

2.09 Summarised descriptions of the standards listed in 2.05

The following relates to the information in the group of standards relevant to prefabricated wall floor and roof elements:

- Standard IS EN 14732-1: June 2003 - *Prefabricated wall, floor and roof elements* - Part 1: *Product requirements* are specified for wood-based semi-rigidly and rigidly built-up, prefabricated wall, floor and roof elements for use in load-bearing structures. The standard references performance requirements as set out in IS EN 14732-2 indicating that mechanical resistance and stiffness of elements to be to the specifications of the design analysis as given in IS EN 1995-1-1. It prescribes that requirements for durability be as set out in IS EN standards 350-1, 350-2, 351-1, 351-2, and also IS EN 13501-1 in regard to reaction to fire, which would also be subject to regulatory requirements and structural fire design in accordance with IS EN 1995-1-2: 2004. It stipulates that thermal conductivities be subject to regulatory requirements, water vapour permeability to comply with IS EN 1931 and formaldehyde emission to be in accordance with the relevant product standard for each particular element of construction.
- Standard IS EN 14732-2: August 2003 - *Prefabricated wall, floor and roof elements* - Part 2: *Performance requirements and minimum production requirements*. The purpose of the requirements of this standard is to obtain elements which maintain their performance throughout the intended life of the structure. It states requirements for the components and minimum requirements for the production of such elements. It provides fifty-eight normative references. It defines a structural component as wood-based joists, wood-based panels and panels from gypsum plasterboard contributing to the structural compound action of an element. It differentiates between a rigid and semi-rigid compound in respect of an element with glued jointed structural components or mechanically jointed structural components respectively. It provides in Annex A a test procedure for determining the minimum bond line shear strength of a joint in a rigid joint panel. Examples of typical element build up comprising panel, joist, glued joint, insulation, staple, nail, exterior non-structural cladding,

diagonal boards and vapour barrier are illustrated. Performance requirements for prefabricated load-bearing elements are given for compliance relative to reliability and durability in respect of joists, panel materials, adhesives for rigid compounds, mechanical fasteners, thermal insulations, vapour barriers, preservative agents, fire protection agents, bond line integrity and strength. The relevant manufacturing requirements are specified in respect of production conditions, equipment, materials, tolerances, assembly of framework and panels and manufacture of glued elements by gluing. Quality control requirements are set out in detail including organisation of factory production control.

This standard is currently within the revision process.

Section 3: Material Properties

3.01 Basis for characteristic values

The characteristic values for strength and stiffness of sawn, glued, laminated veneer lumber and panelboard materials are based on the assumption of a linear relation between stress and strain prior to failure and consequently verification of the load-bearing capacity of individual members in a construction is also based on a similar linear relation except for members subjected to compression loading, for which a non-linear elastic-plastic computation may be used.

3.02 Service class system

Strength values and assessment of deformations under defined environmental conditions are subject to the application of a service class system consisting of three categories, namely, service class 1, service class 2 and service class 3. Service class 1 is relevant to an average materials moisture content of 12 percent at a temperature of 20°C and relative humidity of 65 percent. For service class 2 the corresponding values are 20 percent, 20°C and 85 percent. In service class 3 the climatic conditions would be expected to be in excess of the moisture content of service class 2 conditions.

3.03 Load-duration classes

Duration of load affects the behaviour of timber and wood-based elements over time and consequently also the strength and stiffness properties of these materials. Load duration classes which are required to be applied are as follows:

Designation	Example	Assigned Period:
Permanent :	Self - weight	more than 10 years
Long-term:	Storage	6 months - 10 years

Medium-term:	Imposed loads	1 week - 6 months
Short-term :	Snow, wind	less than one week
Instantaneous:	Wind, accidental	instantly

Note: The duration class and assignment is in accordance with the Irish National Annex of IS EN 1995-1-1

3.04 Partial factors for material properties and resistances

Partial factors for material properties and resistances are used in the following way:

γ_m: is a partial factor for material to take account of the possibility of an unfavourable deviation of a material property from its characteristic value. The values for γ_m partial factors are indicated hereunder and are as given in the Irish National Annex of Eurocode 5.

Fundamental combinations for loading of relevant structural elements:

- Solid timber: 1.30
- Glulam timber: 1.25
- LVL, Plywood, OSB: 1.20
- Particleboards: 1.30
- Fibreboards - hard: 1.30
- Fibreboards - medium: 1.30
- Fibreboards - MDF: 1.30
- Fibreboards - soft: 1.30
- Connections: 1.30
- Punched metal plate fasteners: 1.25
- Accidental combinations: 1.00

k_{mod}: is a partial factor for taking into account the effects on the material of duration of load and moisture content. The values for k_{mod} as given in the Irish National Annex of Eurocode 5 are listed hereunder:

Material	Solid timber			Glulam			LVL		
Service Class:	1	2	3	1	2	3	1	2	3
Permanent:	0.60	0.60	0.50	0.60	0.60	0.50	0.60	0.60	0.50
Long term:	0.70	0.70	0.55	0.70	0.70	0.50	0.70	0.70	0.50
Medium term:	0.80	0.80	0.65	0.80	0.80	0.65	0.80	0.80	0.65
Short term:	0.90	0.90	0.70	0.90	0.90	0.70	0.90	0.90	0.70
Instantaneous:	1.10	1.10	0.90	1.10	1.10	0.90	1.10	1.10	0.90

Material	Plywood			OSB			Particleboard			
Service Class:	1	2	3	1	1	2	1	2	1	2
Permanent:	0.60	0.60	0.50	0.30	0.40	0.30	0.30	0.20	0.40	0.30
Long term:	0.70	0.70	0.55	0.45	0.50	0.40	0.45	0.30	0.50	0.40
Medium term:	0.80	0.80	0.65	0.65	0.70	0.55	0.65	0.45	0.70	0.50
Short term:	0.90	0.90	0.70	0.85	0.90	0.70	0.85	0.60	0.90	0.70
Instantaneous:	1.10	1.10	0.90	1.10	1.10	0.90	1.10	0.80	1.10	0.90

Note:		
	OSB/2 for service class 1	col 1 values
	OSB/3 for service class 1	col 2 values
	OSB/4 for service class 1	col 2 values
	OSB/3 for service class 2	col 3 values
	OSB/4 for service class 2	col 3 values
	P4 + P5 for service class 1	col 1 values
	P5 for service class 2	col 2 values
	P 6; P7 for service class 1	col 3 values
	P7 for service class 2	col 4 values

Material	Fibreboard (hard)		Fibreboard (medium)			Fibreboard (MDF)	
Service Class:	1	2	1	1	2	1	2
Permanent:	0.30	0.20	0.20	0.20	-	0.20	-
Long term:	0.45	0.30	0.40	0.40	-	0.40	-
Medium term:	0.65	0.45	0.60	0.60	-	0.60	-
Short term:	0.85	0.60	0.80	0.80	0.45	0.80	0.45
Instantaneous:	1.10	0.80	1.10	1.10	0.80	1.10	0.80

Note:		
	Fibreboard HB.LA for service class 1	col 1 values
	Fibreboard HB.HLA1 for service class 1	col 1 values
	Fibreboard HB.HLA2 for service class 1	col 1 values

Fibreboard HB.HLA1 for service class 2	col 2 values
Fibreboard HB.HLA2 for service class 2	col 2 values
Fibreboard MBH.LA1 for service class 1	col 3 values
Fibreboard MBH.LA2 for service class 1	col 3 values
Fibreboard MBH.HLS1 for service class 1	col 4 values
Fibreboard MBH.HLS2 for service class 1	col 4 values
Fibreboard MBH.HLS1 for service class 2	col 5 values
Fibreboard MBH.HLS2 for service class 2	col 5 values
Fibreboard MDF.LA for service class 1	col 6 values
Fibreboard MDF.HLS for service class 1	col 6 values
Fibreboard MDF.HLS for service class 2	col 7 values

3.05 Modification factors for deflections and deformations

Modification factors are applied to characteristic values in respect of the different service classes relative to deflections and deformations. The factors are tabulated and referenced k_{def} for timber and wood-based materials in Table 3.2 of IS EN 1995-1-1 and in the Irish National Annex of Eurocode 5: Part 1-1. Where timber is to be installed with a moisture content at or near its saturation level and is likely to dry out under load, the values tabulated require to be increased by 1.00. The modification factor requirements are as shown hereunder:

k_{def}: is the partial factor for material to take account of the possibility of unfavourable deviation of a deformation pattern for timber and wood-based materials in regard to moisture content. The values for k_{def} as given in Irish National Annex of Eurocode 5: Part 1-1 are listed hereunder.

Material		Service Class 1	Service Class 2	Service Class 3
Solid Timber:		0.60	0.80	2.00
Glulam:		0.60	0.80	2.00
LVL:		0.60	0.80	2.00
Plywood 1:		0.80	-	-
Plywood 2:		0.80	1.00	-
Plywood 3:		0.80	1.00	2.50
OSB/2:		2.50	-	-
OSB/3:		1.50	2.25	-
OSB/4:		1.50	2.25	-
Particleboard	P4:	2.25	-	-
	P5:	2.25	3.00	-
	P6:	1.50	-	-
	P7:	1.50	2.25	-
Fibreboard	HB.LA	2.25	-	-
	HB.HLA1	2.25	3.00	-
	HB.HLA2	2.25	3.00	-
	MBH.LA1	3.00	-	-
	MBH.LA2	3.00	-	-
	MBH.HSL1	3.00	4.00	-
	MBH.HSL2	3.00	4.00	-
	MDF .LA	2.25	-	-
	MDF.HLS	2.25	3.00	-

3.06 Durability of materials

Timber and wood-based panels are required to have adequate natural durability in accordance with IS EN 350-2 for the relevant use class or be preservative treated to the requirements of IS EN 351-1 and IS EN 460. Metal fasteners and structural connections are required to be protected against corrosion unless inherently corrosion-resistant. Minimum specification requirements are given in Table 4.1 of IS EN 1995-1-1.

Section 4: Loadings and Actions

4.01 General actions

Eurocode 1: Actions on structures - Part 1-1: General actions - densities, self-weight, imposed loads for buildings includes alternative procedures, values and recommendations for classes where national choices are required to be made. The choices are in the form of Nationally Determined Parameters (NDPs) and are for use for the design of buildings and civil engineering works to be constructed in Ireland and are given in the Irish National Annex of IS EN 1991-1-1 which applies specifically in this country.

4.02 Categories of use

Categories of use and the modifications to be applied in Ireland are listed hereunder together with tabulated imposed loads on floors, balconies and stairs, indicating the recommended values for the different categories set out in the Irish National Annex of Eurocode 1: Part 1-1:

The categories of use are:

A: Sub-divided into Al and A2 for domestic activities and residential activities respectively.

B: Office areas.

C: Areas where people may congregate, sub-divided into five differing arrangements as follows:

- C1: Areas with tables (schools, cafes, restaurants, dining halls, reading rooms and receptions).
- C2: Fixed seat areas (churches, theatres, cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms).
- C3: No obstacle areas for moving people (museums, exhibitions rooms, access areas in public and administration buildings, hotels, hospitals, railway station forecourts).

C4: Physical activity areas (dance halls, gymnastic rooms, stages).

C5: Areas where large crowds can congregate (concert halls, sports halls including stands, terraces, access areas and railway platforms).

D: Shopping areas, subdivided into two areas designated categories, Dl and D2 for general retail shops and department stores respectively.

4.03 Irish National Annex in respect of loadings

The Irish National Annex for Eurocode 1: Part 1-1 provides the following loadings to be used for the design of buildings and civil engineering works which are to be constructed in Ireland, in the context of the categories of use required:

Category:		Imposed udl (q_k):	Concentrated load (Q_k)
A1:	Floors:	1.50 kN/m^2	2.00 kN
	Stairs:	2.00 kN/m^2	2.00 kN
	Balconies:	2.50 kN/m^2	2.00 kN
A2:	Floors:	2.00 kN/m^2	2.00 kN
	Stairs:	2.00 kN/m^2	2.00 kN
	Balconies:	2.50 kN/m^2	2.00 kN
B:	Offices:	3.00 kN/m^2	4.50 kN
C1:	Floors:	3.00 kN/m^2	4.00 kN
C2:	Floors:	4.00 kN/m^2	4.00 kN
C3:	Floors:	5.00 kN/m^2	4.00 kN
C4:	Floors:	5.00 kN/m^2	7.00 kN
C5:	Floors:	5.00 kN/m^2	4.50 kN
D1:	Floors:	4.00 kN/m^2	4.00 kN
D2:	Floors:	5.00 kN/m^2	7.00 kN

Note 1: Other values within the ranges given may be used subject to approval of the client and the regulatory authorities.

Note 2: Category E relates to use for storage including books and other documents.

Note 3: Clause 6.2.1 (4) of Eurocode 1: Part 1-1 permits the reduction of imposed loads from a single category in respect of areas supported by the appropriate member. The reduction factor is specified in clause 6.3.1.2 (10). The

Irish National Annex permits this reduction and also the reduction allowed in clause 6.3.1.2 (11) for total imposed loads from several storeys on columns and walls.

There are two categories of E (E1 and E2) as set out in table 6.3 of Eurocode 1: Part 1-1, namely:

- E1: Areas (including access areas) susceptible to the accumulation of goods such as storage of books and other documents
- E2: Use for industrial activity. Loads require to be assessed in respect of the intended use and the equipment to be installed. Assessment in respect of IS EN 1991-3 (actions induced by cranes and machinery) may be required.

Table 6.4 of clause 6.3.2.2 (values of Actions) stipulates the following in respect of imposed loads on floors due to storage:

Category:	Imposed udl (q_k)	Concentrated load (Q_k)
E1: Floors	7.50 kN/m^2	7.00 kN

The Irish National Annex of Eurocode 1: Part 1-1, requires that the values of table 6.4 are minimum recommended for storage areas. It also stipulates that the height of storage, the density and nature of material being stored shall be taken into account and also that a minimum allowance of 2.5 kN/m^2 per metre height of storage shall be allowed for q_k valuation.

Note: Actions induced by forklifts are not considered in this handbook.

4.04 Imposed loads on roofs

Clause 6.3.4.2 (Table 6.10) of IS EN 1991-1-1 indicates the requirements for imposed loads on roofs of category H (roofs not accessible other than for normal maintenance and repair). The Irish National Annex sets out the requirements for construction in Ireland in accordance with Eurocode 5: Part 1-1 for roofs of category H. The listed stipulations are:

Roof (Category H):	Imposed udl (q_k) 0.75 kN/m^2	Concentrated (Q_k) 1.0 kN

Notes:

a) The value of q_k given is for slopes 0 - 30^o

b) For slopes of 60^o and more q_k is zero

c) Interpolation of intermediate values is permitted

d) The udl load q_k applies to the entire roof area

e) Imposed loads and snow loads or wind actions should not be applied simultaneously.

There are two additional categories of specific use of roofs for which requirements are given in respect of loadings. These are:

- Category I: Roofs accessible with occupancy relative to categories A, B, C and D. Imposed loads for this category (I) are given in tables 6.2, 6.4 and 6.8 of Eurocode 1: Part 1-1.
- Category K: Roofs accessible for special services such as helicopter landing areas. This category of roof construction is not considered in this handbook.

4.05 Horizontal loads on partition walls and on parapets

Eurocode 1: Part 1-1 through clause 6.4 provides the requirements for horizontal loads acting on partition walls and on parapets acting as barriers. The clause requires the characteristic values for q_k acting as a line load at a height not greater than 1.20 m of a partition wall or parapet to be as given in Table 6.12. The table prescribes a range of values for loaded areas in respect of categories A, B, CI, C2, C3, C4, C5, D, and E.

Eurocode 1 allows choice in the National Annex in regard to values within the particular range stipulated. The Irish National Annex provides the following stipulations in regard to works constructed in Ireland:

Category:	Line load (q_k)
A1 and A2:	0.50 kN/m
B and C1:	0.50 kN/m
C2 and C3:	1.00 kN/m
C4 and D:	1.00 kN/m
C5:	3.00 kN/m
E:	1.00 kN/m

Notes:

a) *The value of q_k for category E is a minimum and the specific occupancy for this category requires to be checked and in this context a higher horizontal line load may need to be imposed.*

b) *Where areas are susceptible to significant overcrowding associated with public events at such areas of sports stadia, stands, stages, assembly halls or conference rooms, line load should not be less than category C5 value.*

c) *Grandstands and stadia shall be subject to the requirements of the regulatory authorities in Ireland.*

Section 5: Roof, Floor and Wall Diaphragms

5.01 Basis of strength and stability

Diaphragms constructed of sheathing material fixed to timber members with nails, screws or adhesives form a stiff planar structural element. Such a structural element has the capacity to resist relatively large load actions and to transmit the forces generated by these load actions to the foundations of a building of timber framed construction through end walls or cross walls which have the capacity to do so when acting as shear walls.

5.02 Shear walls

Shear walls are structural elements arranged transversely within or at the ends of a structural timber framed construction. Such walls are formed from sheathing, sawn timber and fasteners. Openings in such walls require to be arranged in a manner which accommodates the structural actions transferred through these walls in order to ensure overall stability of the timber frame construction.

5.03 Design principles

Roof, floor and wall diaphragms are designed in accordance with sub-section 9.2 of IS EN 1995-1-1 and specifically to the requirements of clauses 9.2.3 for roof and floor diaphragms and 9.2.4 for wall diaphragms. Roof and floor diaphragm construction design is based on the simplified analysis given in sub-clause 9.2.3.2 in which the loading is uniformly distributed along the span and the following apply:

- the diaphragm span lies within twice and six times the transverse width.

- the critical ultimate design condition is failure in the fasteners and not in the panels.
- the panels are fixed in accordance with the detailing rules of clause 10.8.1 of sub-section 10.8.

The edge beams are required to be designed to resist the maximum bending moment in the diaphragm unless a more detailed analysis is undertaken. Shear forces in the diaphragm are assumed to be uniformly distributed over its width.

Note: Where roof lights are formed in the construction, specific local bracing is required.

5.04 Requirements for resistance to horizontal and vertical actions

The requirements of clause 9.2.4 for wall diaphragms include design to resist horizontal and vertical actions imposed upon them, adequate restraint to prevent overturning and sliding and also in-plane stiffening to resist racking. The simplified analysis of wall diaphragms — method A given in sub-clause 9.2.4.2, can only be applied when a tie down directly connected to the construction below is in place on the vertical member at the end of the diaphragm. The simplified analysis provides for a method B in sub-clause 9.2.4.3 and in this method resistance to overturning and sliding requires either anchorage to the supporting structure or the application of permanent actions to the wall or a combination of these effects.

5.05 Load-racking capacity and function of a panel

The design of a wall consisting of several panels is determined through the summation of the load-racking capacities of each of the panels. The load-racking capacity of a panel is a function of the lateral design capacity of an individual fastener, the width of the panel, the height of the wall and the spacing of the fasteners. Wall panels which contain an opening for a window or a door should not be considered to contribute

to load-racking capacity. Where wall panels have sheathing on both sides of the timber frame, which is the same type and thickness and where fasteners are similar in type and spacing on each side of the panel, the load-racking capacity of the panel should be taken as the sum of the load-racking capacity of each side. Where a different type of sheet is used for the panels on one side, 75 percent of the load-racking capacity of the weaker side may be taken into consideration, provided that the fasteners on each side have similar slip moduli. Where this is not the case, not more than 50 percent of the weaker side capacity should be taken into consideration.

The external forces arising from the lateral loading can either be transmitted to the sheets in the adjacent wall panel or to the construction situated above or below the panel. Where these forces are tensile and are transmitted to the lower construction, the panel should be anchored by stiff fasteners. Buckling of wall studs is required to be checked in accordance with clause 6.3.2 of Eurocode 5 and where the ends of vertical members bear on horizontal framing members, the compression stress perpendicular to the grain in the horizontal members should be assessed in accordance with clause 6.1.5. Shear buckling of the sheet may be disregarded provided that the ratio of distance between studs and thickness of sheet is equal to or less than 100. The centre stud may be considered to constitute a support for a sheet provided that fastener spacing along it is not greater than twice that along the edges of the sheet.

5.06 Fixings for formation of panels

The fixings in use for the formation of panels consist of:

5.061 Nails	- plain round wire
	- ring shanked
	- annular ringed
	- square twisted
5.062 Other	- staples
	- drive screws
	- adhesives
	- surface coatings

5.07 Design and product specification data for compliance

The normative referenced and other relevant standards listed in Section 2.00 of this handbook provide design and product specification data appropriate for compliance with IS EN 1995-1-1. Nails other than smooth nails as defined in IS EN 14592 or screws should be used for fixing panel sheathing to framed timber. A maximum spacing along the edges of 150 mm and elsewhere a maximum of 300 mm shall be applied for design using the simplified method of analysis, for roof and floor diaphragms, set out in sub-clause 9.2.3.2. The simplified method of analysis for wall diaphragms set out in sub-clauses 9.2.4.2 and 9.2.4.3 assume that panel fixings have a maximum fastener spacing along the edges of 150 mm for nails and 200 mm for screws. The maximum spacing on internal studs should be not more than twice the spacing along the edges or 300 mm, whichever is the lesser.

Section 6: Trusses Fabricated with Metal Plate Fasteners

6.01 Design basis in respect of profile

Roof trusses are designed in accordance with sub-section 5.4 of IS EN 1995-1-1 and specifically to the requirements of sub-clauses 5.4.1 and 5.4.3 using the simplified analyses of trusses with punched metal plate fasteners. These requirements include stipulations that there are no re-entrant angles in the external profile. The truss height shall be greater than 0.15 of the span and 10.0 times the maximum depth of an external member whichever is the greater. The axial forces are derived on the basis that all nodes are pin jointed. Bending moments in single bay members are based on nodes at ends being pinned and bending moments in members that are continuous over several bays on the assumption that the member is a beam with a simple support at each node. The effects of deflection at nodes and partial fixity at connections are taken into account by a reduction of 10 percent on the moments at the inner supports of the member and the resultant moments are used in the calculation of the span bending moments.

6.02 Outline of IS EN 1995-1-1 relevant sub-clauses

Trusses with punched metal plate fasteners are also required to conform to IS EN 14250 and sub-clause 9.2.1 of IS EN 1995-1-1. In this regard matters pertaining to design are given in respect of combined bending and axial forces, effective column lengths for members in compression, strength verification of members in compression and their connections, simplified analysis for trusses loaded at nodes relative to tensile and compressive stress ratios, out of plane stability of truss members, handling and erection stresses, and capacity of joints. In addition, sub-clause 9.2.2 provides requirements for these forms of trusses in which fully triangulated truss forms support a small concentrated load (e.g. a

person load), for minimum overlap dimensions of punched metal plates on any timber member, and for cover dimensions of punched metal plate fasteners used at chord splices.

6.03 Requirements on structural detailing and control compliance

Eurocode 5: Section 10 Part 1-1, provides requirements which are prerequisites for the design rules given in other sections. These rules on structural detailing and control (in production and on site) in respect of trusses with punched metal plate fasteners include:

- limitation of wane, splits, knots and other features in the region of connections to ensure that the load carrying capacity of a connection is not reduced.
- the replacement of members which are warped, split or badly fitting at the time of assembly should be undertaken in such a way that ensures over-stressing of members or connections is avoided.
- The avoidance of over-stressing of members during storage transportation or erection. Where the loaded condition or the support system during construction is different to that in the finished building the interim temporary condition is a relevant load situation which requires to be considered, including in this respect any possible dynamic action.
- taking special care to avoid distortion during hoisting from horizontal to vertical positions.
- the implementation of a control plan in respect of production, workmanship off and on site, and also after completion of the structure.

6.04 Production requirements

Production requirements for prefabricated structural members assembled with punched metal plate fasteners are specified in IS EN 14250. The

standard is in respect of trusses, beams and girders for use in buildings and bridges using structural timber members with or without finger joints. Evaluation of conformity and marking are included. The standard lists nineteen normative standards and stipulates relevant standards in respect of:

- material requirements.
- product requirements.
- reaction to fire.
- timber sizes (minimum sizes).

It also sets out requirements for:

- joints.
- product documentation.
- evaluation of conformity including factory production control.
- marking and certification.

6.05 Draft Irish Standard IS 193: 2006.

Draft Irish Standard - I.S. 193: 2006. Timber trussed rafters for roofs is currently at the public enquiry stage. This draft is a revision of the 1986 version of the original standard. The main differences for the draft are the inclusion of service classes 1 and 2 conditions for trusses, normative references of other standards for compliance including a number of IS EN relevant standards, the introduction of preservation and fire exposure retardant treatments, additional design requirements, an increase in the requirements in respect of fabrication, figures in regard to handling, storage, erection and site work practices. There is an Annex regarding bracing and a second Annex with figures illustrating various items relevant to requirements and a bibliography is included.

The design method described in this standard is based on permissible stress analysis.