Short Course on

DESIGN OF PRECAST CONCRETE JETTY to EUROCODE 2

17-19 August 20120
Pusat Kecermelangan Kejuruteraan dan Teknologi JKR (CREaTE), Melaka

SHORT COURSE ON:

DESIGN OF PRECAST CONCRETE JETTY to EUROCODE 2

Introduction

This course intended to introduce the general principles and considerations involved in the design of maritime structures.The main part of the course will focus on the design of jetty structural elements using precast system based on Eurocode. The course begins with the introduction of precast concrete design concepts and requirements, introduction to Eurocodes, and general design requirements of marine structures. A detail design calculations of various jetty components such as deck slabs, beams, pile caps, ramps and stairs will be discussed. Structural design of pile foundations subject to marine loads will also be explained.

Course objectives/learning outcomes

Upon completion of the course, participants will be able to:

- Identify the basic design criteria of precast systems.
- Describe the design basis, contents and structure of Eurocode.
- Describe the general design principles of maritime structures.
- Design precast reinforced concrete elements of jetty structures using EC2.

Course programme

Day 1: [Facilitator: Prof. Dr. Ahmad Baharuddin Abd Rahman]

Introduction to Precast Concrete System

- Design and construction aspects of precast concrete
- Precast frame stability
- Design of connection: Column to column connection
-` Design of connection: Beam to column connection

Day 2: [Facilitator: Ir. Mohamad Salleh Yassin]

Introduction to Maritime Structures

- Various types of maritime structures, function and terminology
- Design forces on maritime structures: wind, current, waves, berthing and mooring forces, dead, superimposed and live loads.
- Code of practice and design requirements of maritime structures

Introduction to Eurocodes and EC2:

- Structure of Eurocode and EC2
- Design basis, safety factor and actions
- Design for safety, serviceability and durability

Day 3: [Facilitator: Ir. Mohamad Salleh Yassin]

Practical Design of Jetty

- Typical jetty layout plans
- Determination of design specification
- Design of precast deck slabs and beams
- Design of precast pile caps and u-shells
- Design of stairs, ramps and pile foundations

Who should attend?

This short course is intended for young practising civil engineers working in public agencies or private sector, postgraduate students, academicians and consultants who wish to upgrade their knowledge in reinforced concrete design.

Facilitators' profile

- **Professor Dr. Ahmad Baharuddin Abd Rahman** is a Professor at the School of Civil engineering, Universiti Teknologi Malaysia, specializing in steel design and industrialized building systems. He is actively involved in research project related to steel structures and precast concrete construction.

- **Ir. Mohamad Salleh Yassin** is a registered professional engineer who has a wide experience in design of concrete structures. He is currently a senior lecturer at the School of Civil Engineering, UTM, specializing in reinforced and prestressed concrete design. He is actively involved in numerous consultancy projects with consulting firms in design projects related to water retaining structures, buildings and bridges.

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by
Ir. Mohamad Salleh Yassin
School of Civil Engineering
Universiti Teknologi Malaysia

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Learning outcomes

- ✓ Identify the basic design criteria of precast systems.
- ✓ Describe the design basis, contents and structure of Eurocode.
- ✓ Describe the general design principles of maritime structures.
- ✓ Design precast reinforced concrete elements of jetty structures using EC2.

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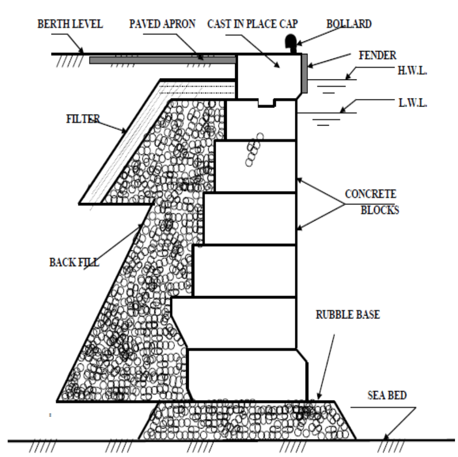
MARINE STRUCTURES

- DOCK
- WHARF / QUAY
- JETTY / PIER
- BREAKWATER
- DOLPHIN
- SLIPWAY
- FENDER

WHARF / QUAY



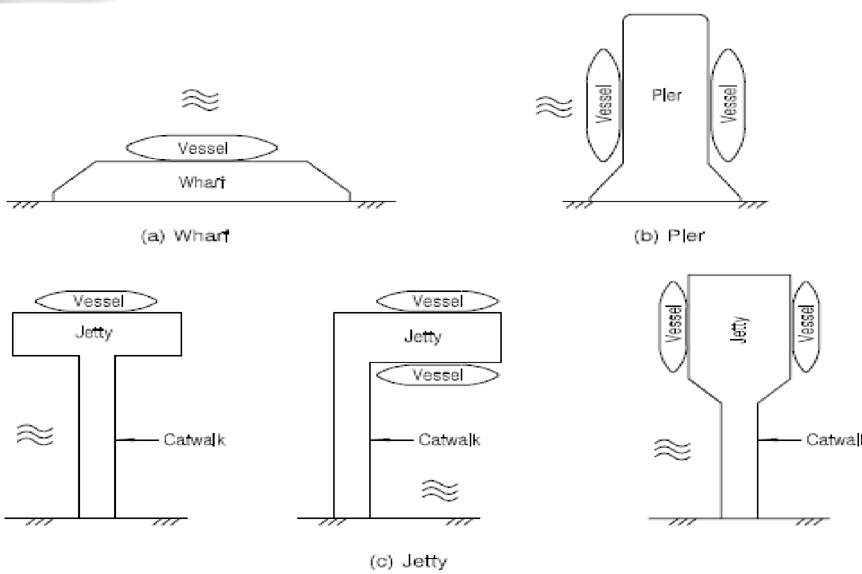
- Platform or landing places in the form of wall built near shores for vessel to berth.
- Provides a working platform along side the ship in continuity of the shore

- Factors affecting design
  - berthing of the ship
  - Handling and storage of cargo
  - Terminal facilities for rail and road transportation

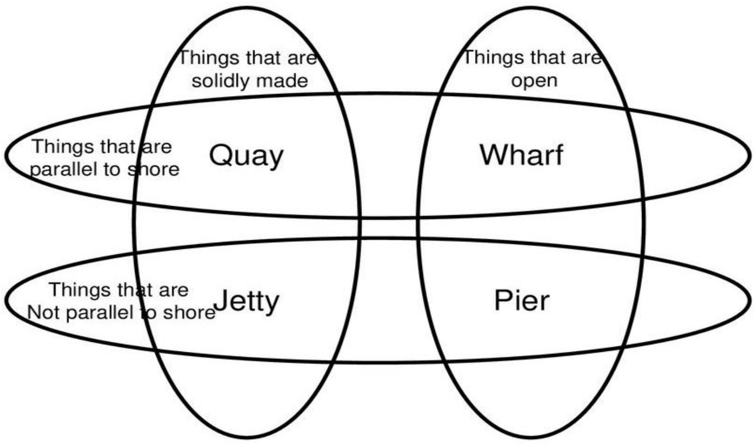
- The quay walls are constructed to retain and protect the filling or embankment on the shore side
- These wall are designed as retaining walls

JETTY / PIER

- Narrow structure projecting from the shore into water with berth on one or both side.
- Provided at places where harbour entrance is affected by littoral drift or long shallow sea

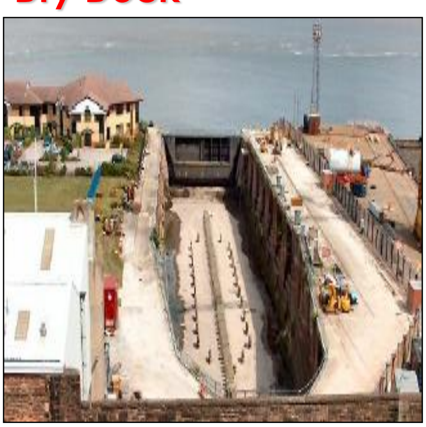

Vessel
Wharf
(a) Wharf
Vessel
Pier
Vessel
(b) Pier
Vessel
Jetty
Catwalk
Vessel
Jetty
Vessel
Catwalk
Vessel
Jetty
Vessel
Catwalk
(c) Jetty

Wharves, Jetties, Piers and Quays Venn Diagram



DOCK

Dry Dock



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Wet Dock

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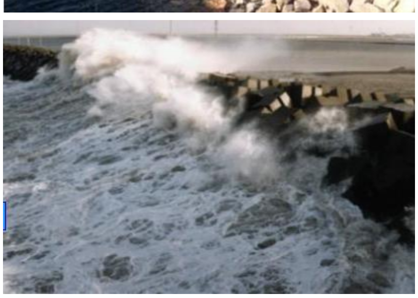
BREAKWATERS



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DOLPHIN

- Structure located at the entrance of a locked basin or along side jetty or wharf to absorb the impact force of the vessel or provide mooring facilities
- Constructed in the form of a cluster of closely spaced piles

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FENDERS

- Cushion provided on the face of jetty on which the ships come in contact with the jetty.
- Protect the structure in a better way from the abrasion of vessel

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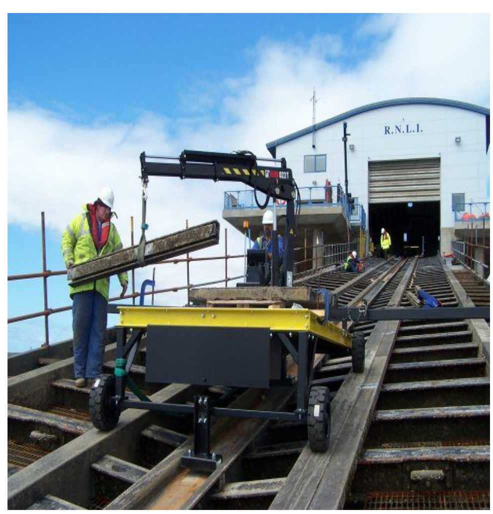
SLIPWAY

- A ramp on the shore by which ships or boats can be moved to and from the water.
- Used for building and repairing ships and boats.

- Slip way extends into water to some length and it is also sufficiently above the high water to accommodate the full length of vessel likely to be drawn out



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MOORING / BOLLARD

- The device used to anchor or attach a vessel in a harbour.
- Thick post or port designed to take up pulls up to 350 kN.
- Provided either by single bit or double bit

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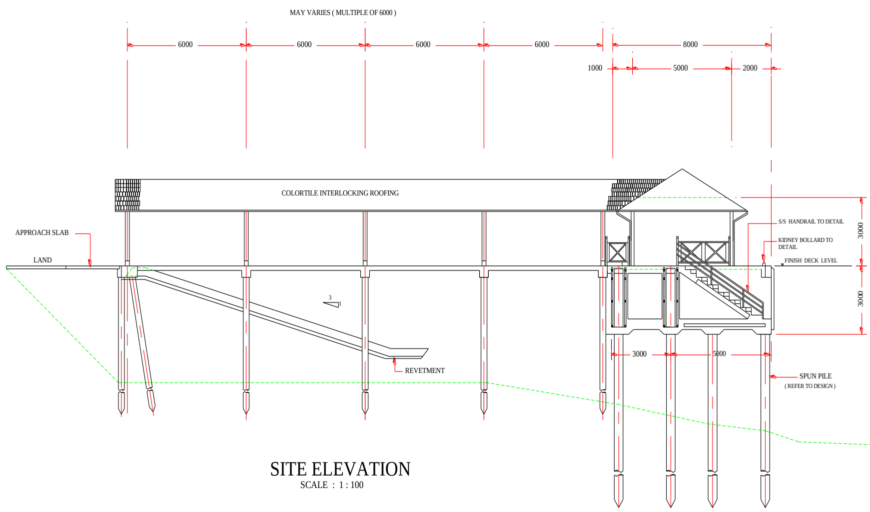
DESIGN OF JETTY

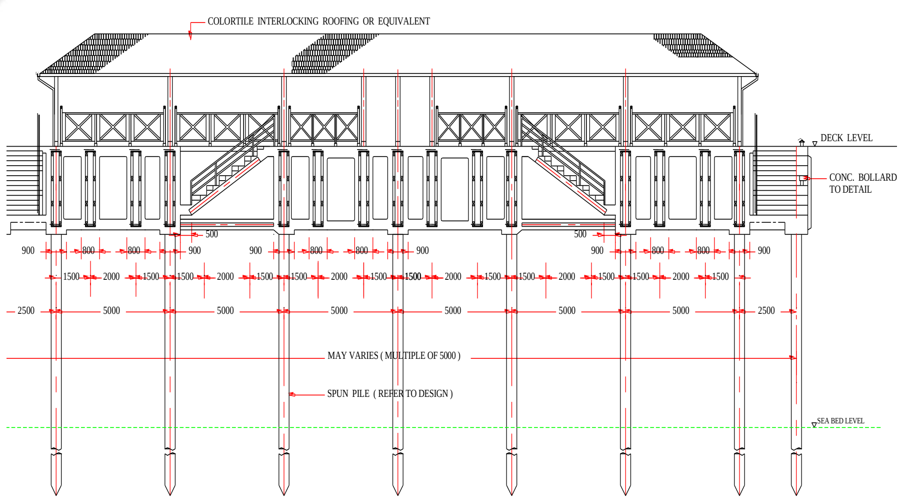
- Architectural Drawings
- Structural layout
- Design Specification
- Structural Design
  - Deck slabs
  - Secondary beams
  - Main beams / Pile caps
  - Piling

Architectural drawings

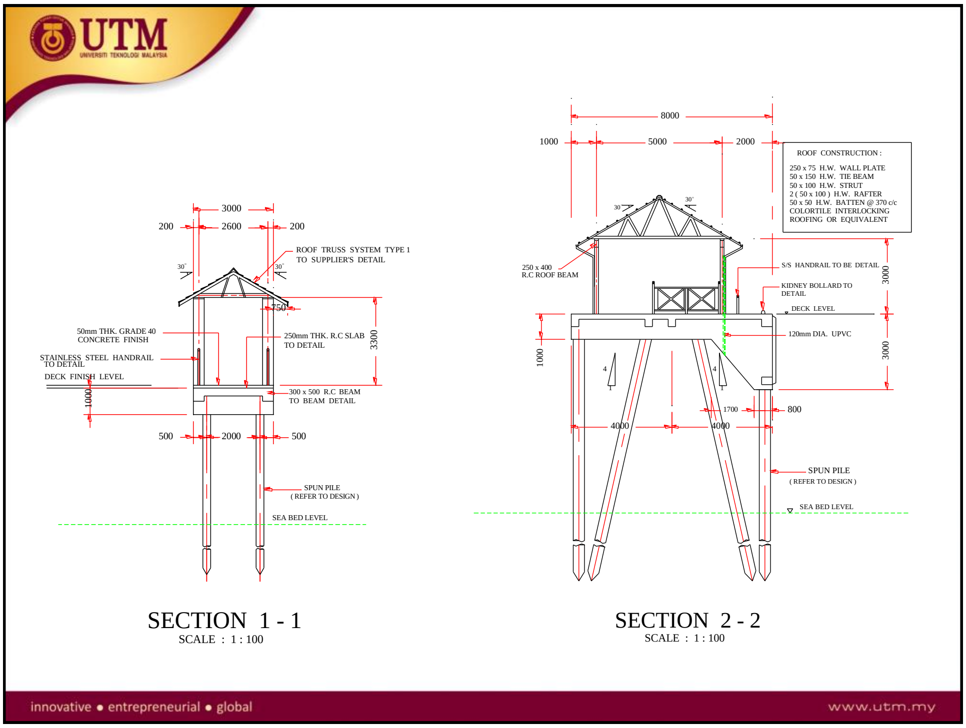


SITE ELEVATION

SCALE : 1 : 100



FRONT ELEVATION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ROOF CONSTRUCTION :
250 x 75 H.W. WALL PLATE
50 x 150 H.W. TIE BEAM
50 x 100 H.W. STRUT
2 (50 x 100) H.W. RAFTER
50 x 50 H.W. BATTEN @ 370 c/c
COLORTILE INTERLOCKING
ROOFING OR EQUIVALENT
ROOF TRUSS SYSTEM TYPE 1
TO SUPPLIER'S DETAIL
50mm THK. GRADE 40
CONCRETE FINISH
STAINLESS STEEL HANDRAIL
TO DETAIL
DECK FINISH LEVEL
250mm THK. R.C SLAB
TO DETAIL
300 x 500 R.C BEAM
TO BEAM DETAIL
SPUN PILE
(REFER TO DESIGN)
SEA BED LEVEL
250 x 400
R.C ROOF BEAM
S/S HANDRAIL TO BE DETAIL
KIDNEY BOLLARD TO
DETAIL
DECK LEVEL
120mm DIA. UPVC
SECTION 1 - 1
SCALE : 1 : 100
SECTION 2 - 2
SCALE : 1 : 100
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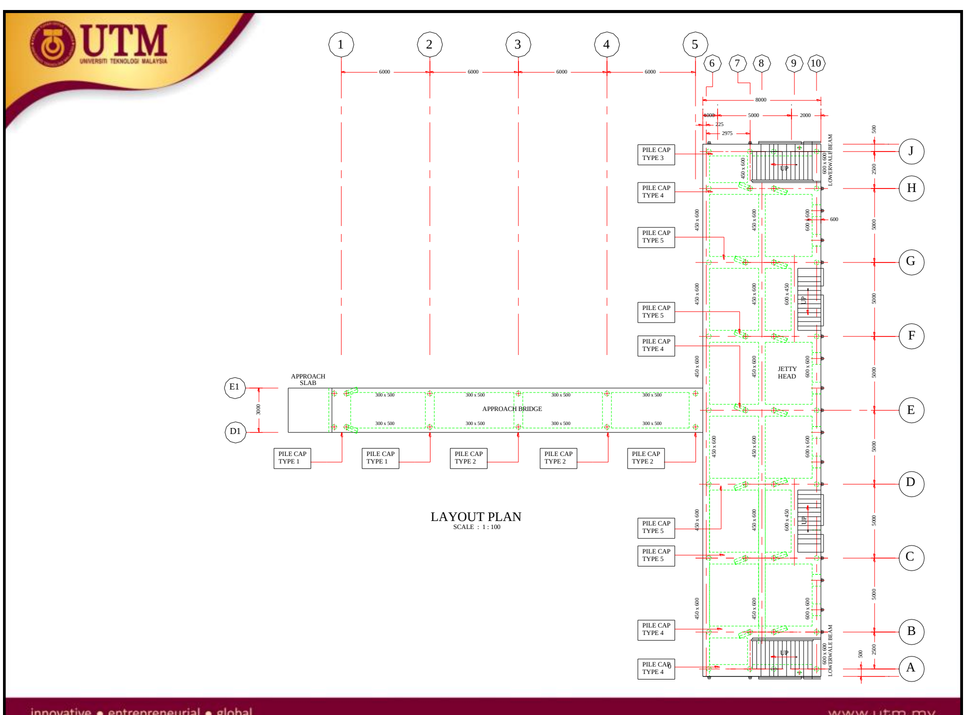
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PILE CAP TYPE 1
PILE CAP TYPE 2
PILE CAP TYPE 3
PILE CAP TYPE 4
PILE CAP TYPE 5
APPROACH SLAB
APPROACH BRIDGE
JETTY HEAD
UP
LAYOUT PLAN
SCALE : 1 : 100
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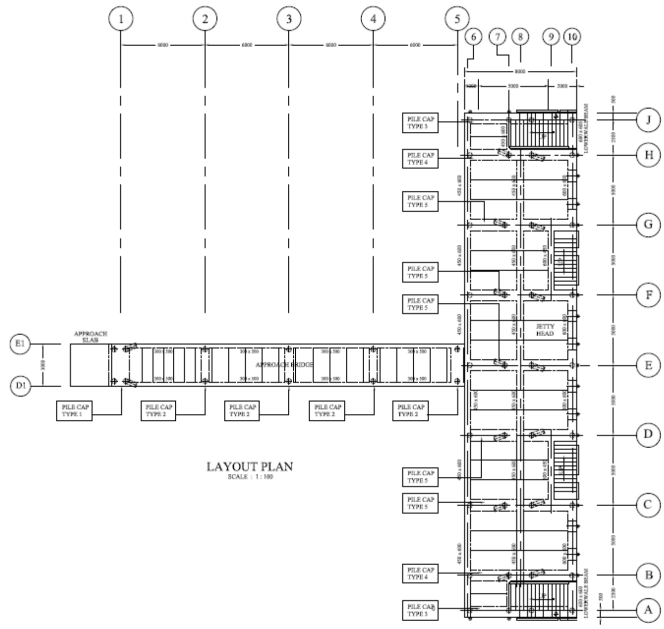
Structural layout



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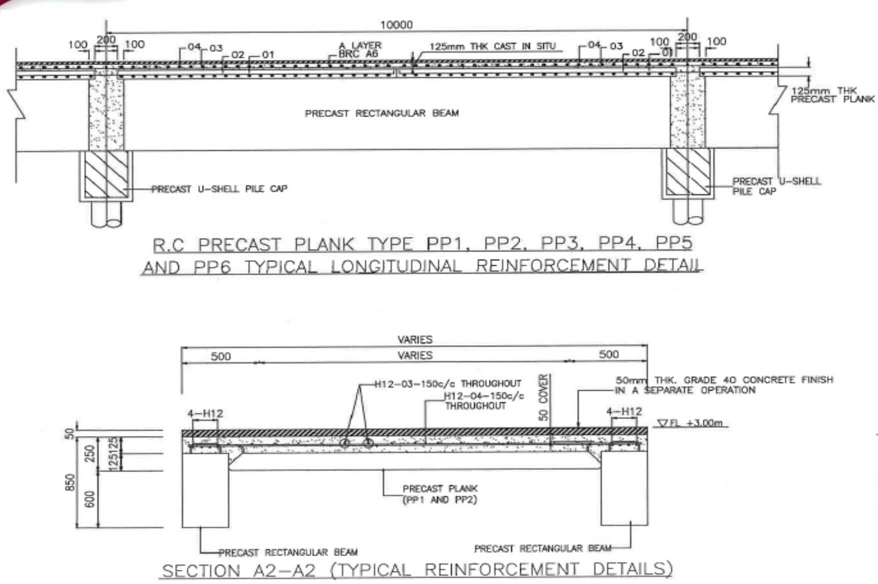

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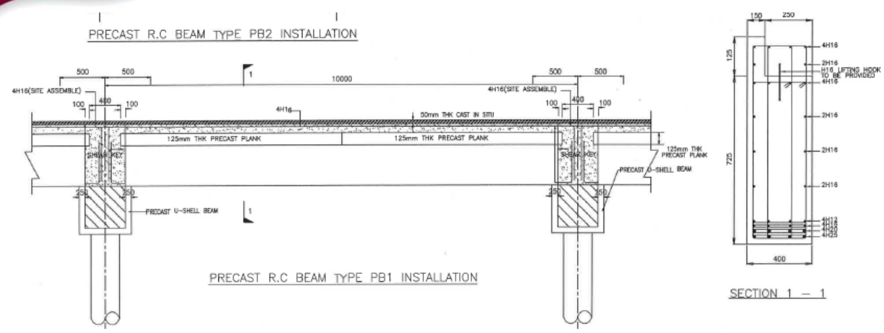

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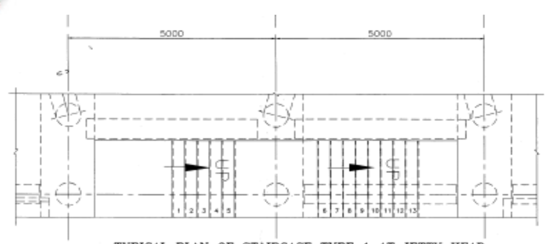
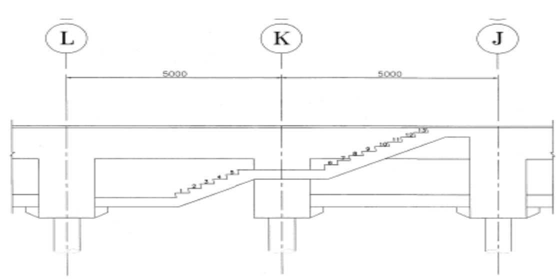


TYPICAL PLAN OF STAIRCASE TYPE 1 AT JETTY HEAD
SCALE 1:50



TYPICAL FRONT ELEVATION OF STAIRCASE TYPE 1
SCALE 1:50

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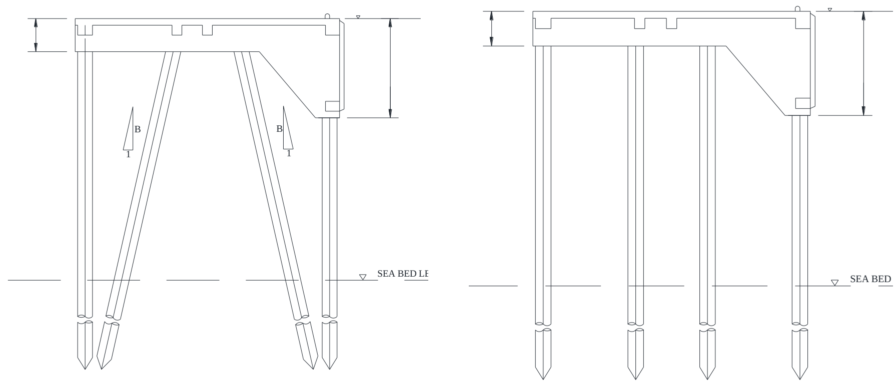

Design Specification

- Code of Practice and Guidelines
- Category and Types of Structure
- Design life
- Exposure Class
- Fire Resistance
- Materials
- Actions

Code of Practice and Guidelines

BS 6349-1: 2000
Maritime Structures – Code of practice for general criteria

BS 6349-1-2:
Maritime Works – Code of practice for assessments of actions

BS 6349-1-3: 2012
Maritime Works – Code of Practice for geotechnical design

BS 6349-1-4: 2013
Maritime Works – Code of practice for materials

BS 6349-3: 2013
Maritime Works – Code of practice for the design of shipyards and sea lock

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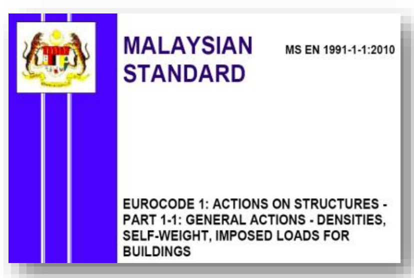

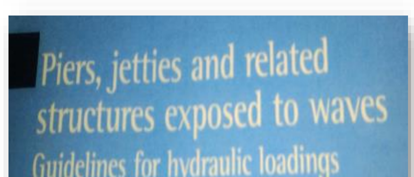

By: *Kirsty McConnell, William Allsop, Ian Cruickshanl,* Thomas Telford, 2004

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PORT WORKS DESIGN MANUAL
Part 1; General design considerations for Marine Works
Part 2: Guide to design of piers and Dolphins
Civil Engineering Office, Civil Engineering Department
The Government of the Hong Kong Special Administrative Region

NSW MARITIME
ENGINEERING STANDARDS AND GUIDELINES FOR MARITIME STRUCTURES , March 2005

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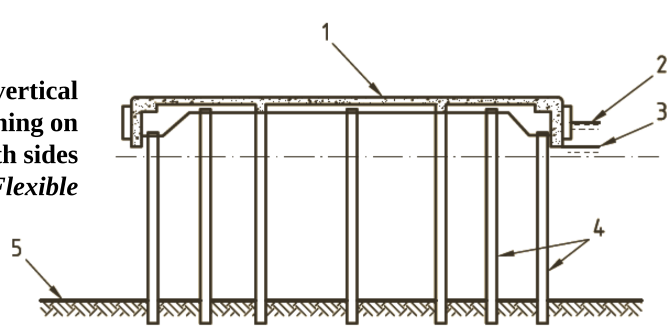
Category and Types of Structure

1. Solid
2. Open-piled : Rigid or Flexible

Suspended deck structures

Jetty with all vertical piles and berthing on both sides
Flexible



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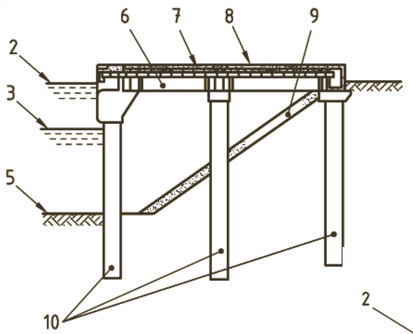
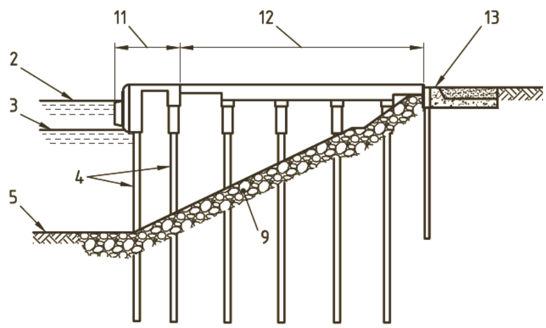
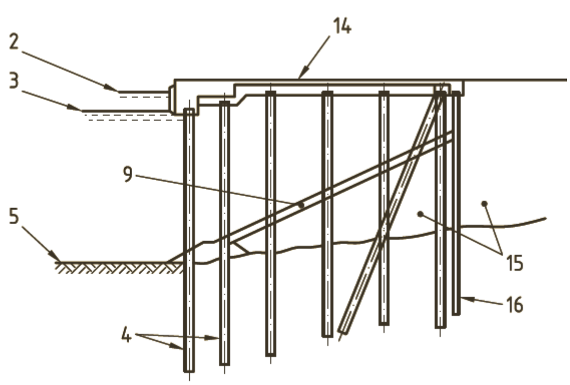


Jetty with all vertical large diameter piles
Partly flexible and partly rigid



Jetty with all vertical piles plus struts to shore
Rigid

Jetty with vertical and racking piles
Rigid



Notation:

1. Reinforced concrete deck
2. High water level
3. Low water level
4. Piles
5. Bed level
6. Precast concrete beam
7. Precast concrete slab
8. Insitu concrete decking
9. Rock armour
10. Large diameter piles
11. Quay
12. Access bridge acts as strut
13. Shore abutment
14. Reinforced concrete beam and slab
15. Granular fill
16. Retaining wall

Design working life

Table 2.1: EN 1990

Design working life category	Indicative design working life (years)	Examples
1	10	Temporary structures
2	10 to 25	Replaceable structural parts, e.g. gantry girders, bearing
3	15 to 30	Agricultural and similar structures
4	50	Buildings structures and other common structures
5	100	Monumental building structures, bridges, and other civil engineering structures

Exposure Class

EN 1992-1-1:2004

Table 4.1: Exposure classes related to environmental conditions in accordance with EN 206-1

Class designation	Description of the environment	Informative examples where exposure classes may occur
2 Corrosion induced by carbonation		
XC1	Dry or permanently wet	Concrete inside buildings with low air humidity Concrete permanently submerged in water
XC2	Wet, rarely dry	Concrete surfaces subject to long-term water contact Many foundations
XC3	Moderate humidity	Concrete inside buildings with moderate or high air humidity External concrete sheltered from rain
XC4	Cyclic wet and dry	Concrete surfaces subject to water contact, not within exposure class XC2
4 Corrosion induced by chlorides from sea water		
XS1	Exposed to airborne salt but not in direct contact with sea water	Structures near to or on the coast
XS2	Permanently submerged	Parts of marine structures
XS3	Tidal, splash and spray zones	Parts of marine structures

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Materials

EN 206-1:2000 Concrete

Table F.1 — Recommended limiting values for composition and properties of concrete

	Exposure classes																	
	No risk of corrosion or attack	Carbonation-induced corrosion				Chloride-induced corrosion						Freeze/thaw attack				Aggressive chemical environments		
						Sea water			Chloride other than from sea water									
	X0	XC 1	XC 2	XC 3	XC 4	XS 1	XS 2	XS 3	XD 1	XD 2	XD 3	XF 1	XF 2	XF 3	XF 4	XA 1	XA 2	XA 3
Maximum w/c	—	0,65	0,60	0,55	0,50	0,50	0,45	0,45	0,55	0,55	0,45	0,55	0,55	0,50	0,45	0,55	0,50	0,45
Minimum strength class	C12/15	C20/25	C25/30	C30/37	C30/37	C30/37	C35/45	C35/45	C30/37	C30/37	C35/45	C30/37	C25/30	C30/37	C30/37	C30/37	C30/37	C35/45
Minimum cement content (kg/m^3)	—	260	280	280	300	300	320	340	300	300	320	300	300	320	340	300	320	360
Minimum air content (%)	—	—	—	—	—	—	—	—	—	—	—	—	4,0[a]	4,0[a]	4,0[a]	—	—	—
Other requirements												Aggregate in accordance with EN 12620 with sufficient freeze/thaw resistance					Sulfate-resisting cement[b]	

EN 1992-1-1:2004 Steel reinforcement

Table C.1: Properties of reinforcement

Product form	Bars and de-coiled rods			Wire Fabrics			Requirement or quantile value (%)
Class	A	B	C	A	B	C	-
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)	400 to 600						5,0
Minimum value of $k = (f_t/f_y)_k$	≥1,05	≥1,08	≥1,15 <1,35	≥1,05	≥1,08	≥1,15 <1,35	10,0
Characteristic strain at maximum force, ε_{uk} (%)	≥2,5	≥5,0	≥7,5	≥2,5	≥5,0	≥7,5	10,0
Bendability	Bend/Rebend test			-			
Shear strength	-			0,3 A f_{yk} (A is area of wire)			Minimum

Fire resistance

Appendix E

Minimum Periods of Fire Resistance for Elements of Structure

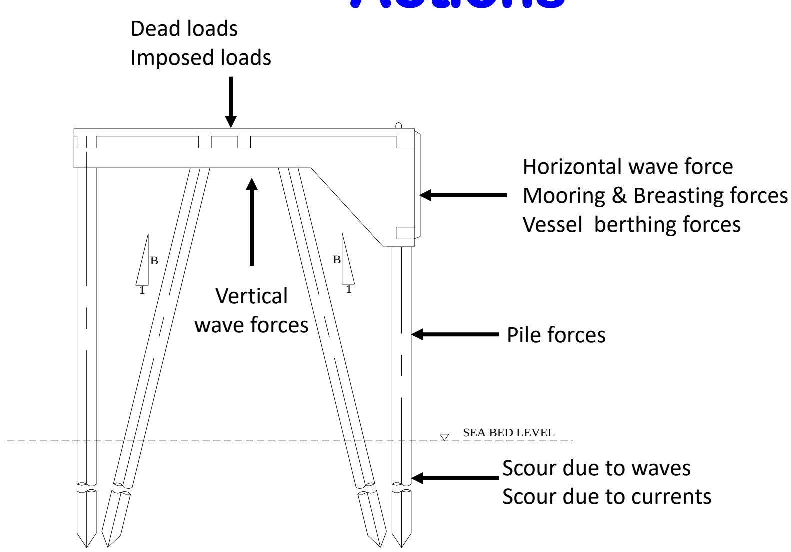
[By-law 143(3), 148, 159(1), 163, 214, 217(2)]

(Source: , Uniform Building By-Law 1984, International Law Book Services, 2003)

PART 2 - Single storey buildings

Purpose group	*Maximum floor area (m²)*	*Minimum period of fire resistance for elements of structure (hours)*
(1)	(2)	(3)
I Small residential	No limit	½
II Institutional	3000	½
III Other residential	3000	½
IV Office	3000 No limit	½ 1
V Shop	2000 3000 No limit	½ 1 2
VI Factory	2000 3000 No limit	½ 1 2
VII Assembly	3000 No limit	½ 1
VI Storage and general	500 1000 3000 No limit	½ 1 2 4

Actions



The importance of hydraulic actions on open piled jetty

Type of forces	Level of importance
Horizontal wave load	Frequent but moderate significance
Wave overtopping loads	Usually ignored but can be dangerous
Uplift forces	Seldom predicted, no reliable methods
Wave slam or impact forces	Not well predicted
Vessel mooring loads	Significant
Vessel berthing load	May be critical
Bed scour	Only local and for limited cases

INTRODUCTION TO EUROCODES

By:
Ir. Mohamad Salleh Yassin
School of Civil Engineering
Universiti Teknologi Malaysia

Introduction

- ❑ Structural Eurocodes are a set of harmonized European standards for the design of buildings and civil engineering structures.
- ❑ Developed over twenty-five years (Started since 1975)
- ❑ March 2010 they have effectively replaced the British Standard as the primary basis for designing buildings and civil engineering structures in the UK

The suite of Structural Eurocodes represent:

- ❑ The most advanced technical views prepared by the best informed groups of experts in their fields across Europe
- ❑ The most comprehensive treatment of the subjects, with many aspects not previously codified now being covered by agreed procedures

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- Eurocodes have been developed to improve the competitiveness of the European construction industry both within and outside the European Union

- provide common design criteria and common understanding regarding the design of structures between owners, operators and users, designers.

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- Eurocode is actually a performance code which has more advantages over British Standard, which is a descriptive code.

- The utilisation of the Eurocode will be beneficial in the long term. It is a state-of-the art code and contains many improvements which one cannot fine in the British Standard.

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- Eurocodes lead to a modest but significant improvement in economy compared to existing British Standards.
- In concrete design it is expected that there will be material cost savings of up to 5% compared with using BS 8110.

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Countries outside EC expected to adopt Eurocode

Have decided: Malaysia, Vietnam, Singapore

Showing keen interest:

China, India, Sri Langka, South Africa, Australia, Japan, South Korea and Gulf countries.

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The Eurocodes

The Eurocode Family (58 all together)		
EN 1990	Eurocode	Basis of structural design
EN 1991	Eurocode 1	Actions on structures
EN 1992	Eurocode 2	Design of concrete structures
EN 1993	Eurocode 3	Design of steel structures
EN 1994	Eurocode 4	Design of composite steel and concrete structures
EN 1995	Eurocode 5	Design of timber structures
EN 1996	Eurocode 6	Design of masonry structures
EN 1997	Eurocode 7	Geotechnical design
EN 1998	Eurocode 8	Design of structures for earthquake resistance
EN 1999	Eurocode 9	Design of aluminium alloy structures

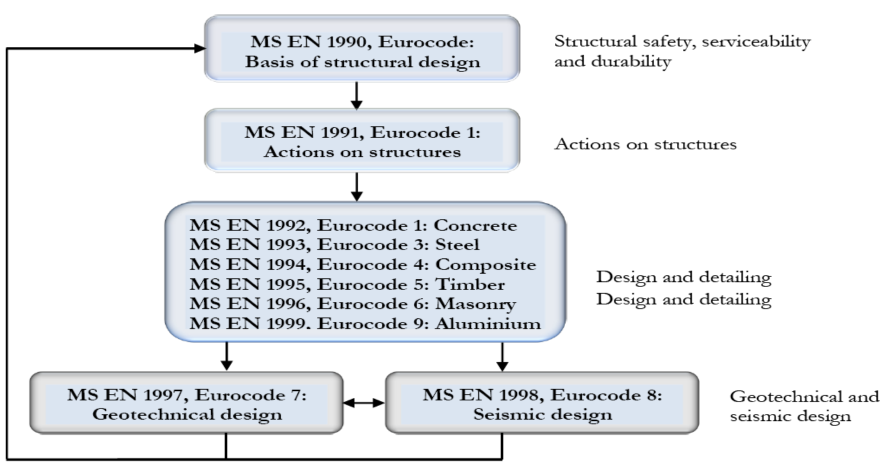

Figure 1.5 Organization and links between the Eurocodes

EUROCODE 1 : ACTIONS ON STRUCTURES	
EN 1991-1-1	Densities, self weight and imposed loads
EN 1991-1-2	Actions on structures exposed to fire
EN 1991-1-3	Snow loads
EN 1991-1-4	Wind loads
EN 1991-1-5	Thermal loads
EN 1991-1-6	Actions during execution
EN 1991-1-7	Accidental actions
EN 1991-2	Traffic loads on bridges
EN 1991-3	Actions induced by cranes and machinery
EN 1991-4	Silos and tanks

EUROCODE 2 : DESIGN OF CONCRETE STRUCTURES	
EN 1992-1-1	General rules and rules for buildings
EN 1992-1-2	General rules – Structural fire design
EN 1992-2	Concrete bridges – design and detailing rules
EN 1992-3	Liquid retaining and containment structures

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Format of the Eurocodes

- Each Eurocode contains:
  - National Fowarded
  - Main text and Annexes
  - National Annex

- National annex gives Nationally Determined Parameters (NDPs)

- NDPs have been allowed for reason of safety, economy and durability

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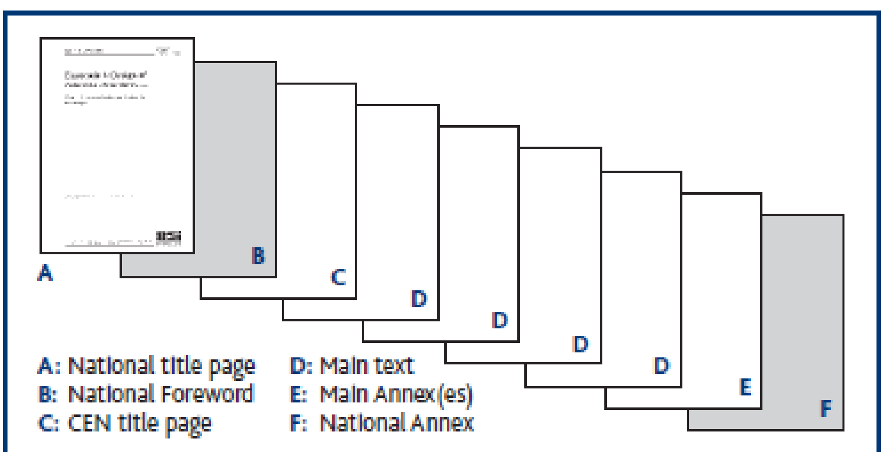
Format of the Eurocodes



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There are two types of annex in the Eurocodes.

- Normative annexes are part of the requirements of the code.
- Informative annexes provide guidance that can be adopted or not on a country by country basis.

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- The family of Eurocodes is based on principles rather than methods
- Format of all codes is: principles, materials, ultimate, service, detailing
- All materials are subjected to the same limit state regime

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EN 1990 :EUROCODE Basis of structural design

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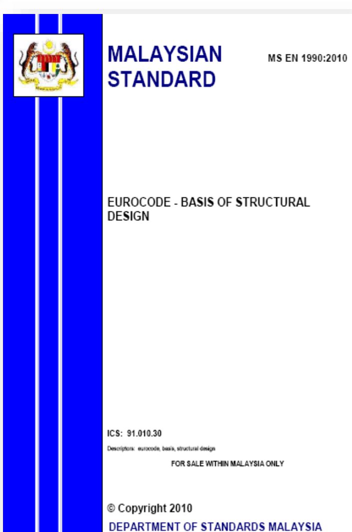
EN 1990


MALAYSIAN STANDARD

MS EN 1990:2010

EUROCODE - BASIS OF STRUCTURAL DESIGN

ICS: 91.010.30

Descriptors: eurocode, basis, structural design

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DEPARTMENT OF STANDARDS MALAYSIA

Contents	
Section 1	General
Section 2	Requirements
Section 3	Principles of Limit State Design
Section 4	Basic variables
Section 5	Structural analysis and design assisted by testing
Section 6	Verification by the partial factor method
Annex A1	Application for buildings
Annex A2	Application for bridges
Annex B	Management of structural reliability for construction works
Annex C	Basis for partial factor design and reliability analysis
Annex D	Design assisted by testing

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1.1 Scope

(1) EN 1990 establishes Principles and requirements for safety, serviceability and durability of structures, describes the basis for their design and verification and gives guidelines for related aspects of structural reliability.

(2) EN 1990 is intended to be used in conjunction with EN 1991 to 1999 for the structural design of buildings and civil engineering works, including geotechnical aspects, structural fire design, situations involving earthquakes, execution and temporary structures

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(3) EN 1990 is applicable for the design of structures where other materials or other actions outside the scope of EN 1991 to 1999 are involved.

(4) EN 1990 is applicable for the structural appraisal of existing construction, in developing the design of repairs and alterations or in assessing changes of use.

1.3 The general assumption 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 carried out by personnel having appropriate skill and experience;
- adequate supervision and quality control is provided during execution of the work, i.e. in design office, factories, plant, and on sites;

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- the construction materials and products are used as specified in EN 1990 or in EN 1991 to EN 1999 or in the relevant execution standards, or reference material or product specifications;
- the structure will be adequately maintained;
- The structure will be used in accordance with the design assumptions.

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1.4 Distinction between Principles and Application Rules

(1) Depending on the character of the individual clauses, distinction is made in EN 1990 between Principles and Application Rules.

(2) The Principles comprise:
- general statements and definitions for which there is no alternatives, as well as;
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The Principles are identified by letter P following the paragraph number

(4) The Application Rules are generally recognised rules which comply with the Principle and satisfy their requirements.

(5) It is permissible to use alternative design rules different from Application Rules given in EN 1990 for works, provided that it is shown that the alternative rules accord with the relevant Principles and are at least equivalent with regard to the structural safety, serviceability and durability which would be expected when using the Eurocodes.

(6) In EN 1990, the Application Rules are identified by a number in bracket.

Section 2: Requirements

2.1 Basic Requirements

(1)P A structure shall be designed and executed in such a way that it will, during its intended life, with appropriate degrees of reliability and in an economical way
- sustain all actions and influences likely to occur during execution and use, and
- remain fit for use for which it is required.

(2)P A structure shall be designed to have adequate:
- structural resistance
- serviceability, and
- durability

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2.3 Design working life

Design working life category	Indicative design working life (years)	Examples
1	10	Temporary structures
2	10 to 25	Replaceable structural parts, e.g. gantry girders, bearing
3	15 to 30	Agricultural and similar structures
4	50	Buildings structures and other common structures
5	100	Monumental building structures, bridges, and other civil engineering structures

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Section 3 : Principle of limit states design

3.2 Design situations

Persistent : - Design situation during a period of the same order as he design working life of the structure.
- Represents normal use

Transient: - Design situation during a period much shorter than the design working life of the structure.
- e.g. during execution or repair

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Accidental: - Design situation involving exceptional conditions for structure.

- e.g. Fire, explosion, impact etc

Seismic: - Design situation involving exceptional conditions for structure during seismic event.

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3.3 Ultimate limit states

(1)P The limit states that concern;
- the safety of people, and/or
- the safety of the structure.

3.4 Serviceability limit states

(1)P The limit states that concern;
- the functioning of the structure or structural members under normal use;
- the comfort of people
- the appearance of the construction works.

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Section 4 : Basic variables

4.1 Actions and environmental influences
4.1.1 Classification of actions

(1)P Actions shall be classified by their variations in time as follows:

- permanent actions (G), e.g. Self-weight of structures, fixed equipment and road surfacing, and indirect actions caused by shrinkage and uneven settlements;
- variable actions (Q), e.g. Imposed loads on building floors, beams and roofs, wind actions or snow loads;
- accidental action (A), e.g. Explosion, or impact from vehicles.

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For each variable actions there are four representative values:

1. Characteristic value, (Q_k) – an upper value with an intended probability of not being exceeded or a lower value with an intended probability of being achieved, during some specific reference period

2. Combination value, ($\psi_o Q_k$) – value intended to take account of a reduced probability of the simultaneous occurrence of two or more variable actions.

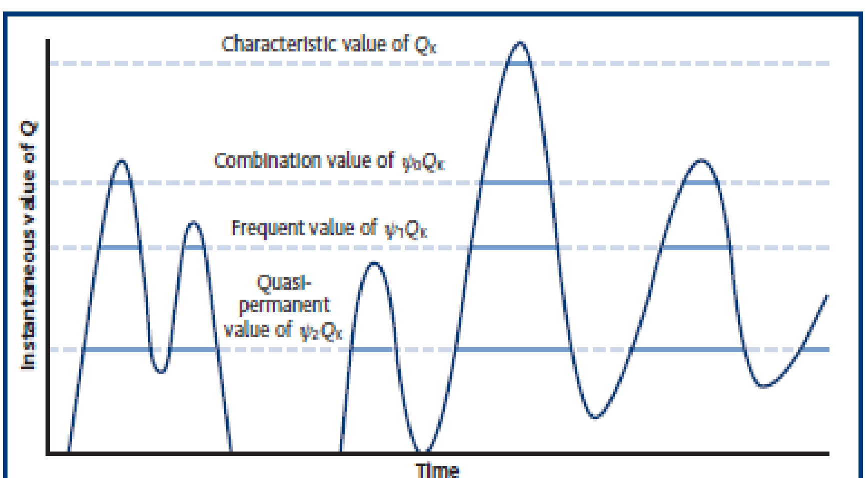
3. Frequent value, ($\psi_1 Q_k$) – value such that it should be exceeded only for a short period of time and is used primarily for the serviceability limit states and also accidental limit state.

4. Quasi-permanent value, ($\psi_2 Q_k$) – value may be exceeded for a considerable period of time; alternatively it may be considered as an average loading over time. It is used for a long term affects at the SLS and also accidental and seismic ULS.

Recommended values of ψ factors for buildings

Action	ψ_0	ψ_1	ψ_2
Imposed loads in buildings (see EN 1991-1-1)			
Category A: domestic, residential areas	0.7	0.5	0.3
Category B: office areas	0.7	0.5	0.3
Category C: congregation areas	0.7	0.7	0.6
Category D: shopping areas	0.7	0.7	0.6
Category E: storage areas	1.0	0.9	0.8
Category F: traffic area, vehicle weight < 30 kN	0.7	0.7	0.6
Category G: traffic area, 30 kN < vehicle weight < 160 kN	0.7	0.5	0.3
Category H: roof (see EN 1991-1-1: Cl. 3.3.2)	0.7	0	0
Wind loads on buildings (see EN 1991-1-4)	0.5	0.7	0.7
Temperature (non-fire) in buildings (see EN 1991-1-5)	0.6	0.7	0.7

Representative values of variable actions



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Combination of actions

▪"Combination of action" is specifically used for the definition of the magnitude of actions to be used when a limit state is under the influence of different actions.

▪"Load cases" is concerned with the arrangement of the variable actions to give the most unfavourable conditions.

▪Where there is only one variable actions (e.g. Imposed load) in a combination, the magnitude of the actions can be obtained by multiplying them by the appropriate factors.

▪Where there is more than one variable actions in combination, it is necessary to identify the leading action($Q_{k,1}$) and other accompanying actions ($Q_{k,i}$). The accompanying actions is always taken as the combination value.

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6.4 Ultimate Limit State

The ultimate limit states are divided into the following categories;

- **EQU** Loss of equilibrium of the structure
- **STR** Internal failure or excessive deformation of the structure or structural member
- **GEO** Failure due to excessive deformation of the ground
- **FAT** Fatigue failure of the structure or structural member

For persistent and transient design situation under the STR limit state, the Eurocode defines three possible combination as follows;

Table A1.2(B) : Design values of actions- Ultimate limit states for persistent and transient design situation

Combination Expression	Permanent actions		Leading variable actions	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
Exp. (6.10)	$\gamma_{Gj,sup}\, G_{kj,sup}$	$\gamma_{Gj,inf}\, G_{k,j,inf}$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i}\ \psi_{0,i}\ Q_{k,i}$
Exp. (6.10a)	$\gamma_{Gj,sup}\, G_{kj,sup}$	$\gamma_{Gj,inf}\, G_{k,j,inf}$		$\gamma_{Q,1}\ \psi_{0,1}\ Q_{k,1}$	$\gamma_{Q,i}\ \psi_{0,i}\ Q_{k,i}$
Exp. (6.10b)	$\xi\gamma_{Gj,sup}\, G_{kj,sup}$	$\gamma_{Gj,inf}\, G_{k,j,inf}$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i}\ \psi_{0,i}\ Q_{k,i}$

Notes:
1. The choice between 6.10, or 6.10a and 6.10b will be in the National annex.
2. The γ and ξ values may be set by the National annex. The following values for γ and ξ are recommended when using 6.10, 6.10a and 6.10b. $\gamma_{Gj,sup}$ = 1.35, $\gamma_{Gj,inf}$ = 1. 0 $\gamma_{Q,1}$ = 1.50 where Unfavourable (0 where favourable)
   $\gamma_{Q,i}$ = 1.50 where Unfavourable (0 where favourable) ξ = 0.85

Design values of actions, ultimate limit state-persistent and transient design situations

Combination Expression	Permanent actions		Leading variable actions	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
Exp. (6.10)	$1.35G_k$	$1.0G_k$	$1.5Q_k$		$1.5\psi_{0,i}Q_{k,i}$
Exp. (6.10a)	$1.35G_k$	$1.0G_k$		$1.5\psi_{0,1}Q_k$	$1.5\psi_{0,i}Q_{k,i}$
Exp. (6.10b)	$0.925x1.35G_k$	$1.0G_k$	$1.5Q_k$		$1.5\psi_{0,i}Q_{k,i}$

Note:
1. Design for either Exp.(6.10) or the less favourable of Exp. (6.10a) and (6.10b)
2. The terms favorable and unfavorable refer to the effect of the action on the design situation under consideration. For example, if a beam, continuous over several spans, is to be designed for largest sagging bending moment it will have to sustain any action that has the effect of increasing the bending moment will be considered unfavorable whilst any action that reduces the bending moment will be considered to be favourable.

Table A1.4 : Design values of actions- Serviceability limit states

Combination	Permanent actions, G_d		Variable actions, Q_d	
	Unfavourable	Favourable	Leading	Others
Characteristic	$G_{kj,sup}$	$G_{k,j,inf}$	$Q_{k,1}$	$\psi_{0,i}\ Q_{k,i}$
Frequent	$G_{kj,sup}$	$G_{k,j,inf}$	$\psi_{1,1}\ Q_{k,1}$	$\psi_{2,i}\ Q_{k,i}$
Quasi-permanent	$G_{kj,sup}$	$G_{k,j,inf}$	$\psi_{2,1}\ Q_{k,1}$	$\psi_{2,i}\ Q_{k,i}$

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Design values of actions, serviceability limit states

Combination	Permanent actions		Variable actions		Example of use
	Unfavourable	Favourable	Leading	Others	
Characteristic	$1.0G_k$	$1.0G_k$	$Q_{k,1}$	$\psi_{0,i}Q_{k,i}$	
Frequent	$1.0G_k$	$1.0G_k$	$\psi_{1,1}Q_{k,1}$	$\psi_{2,1}Q_{k,i}$	Cracking – prestressed concrete
Quasi-permanent	$1.0G_k$	$1.0G_k$	$\psi_{2,1}Q_{k,1}$	$\psi_{2,1}Q_{k,i}$	Deflection

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