Store stålbroer (ESDEP-uddrag)

bjælkebroer samt skråtags- og hængebroer : figurhæfte

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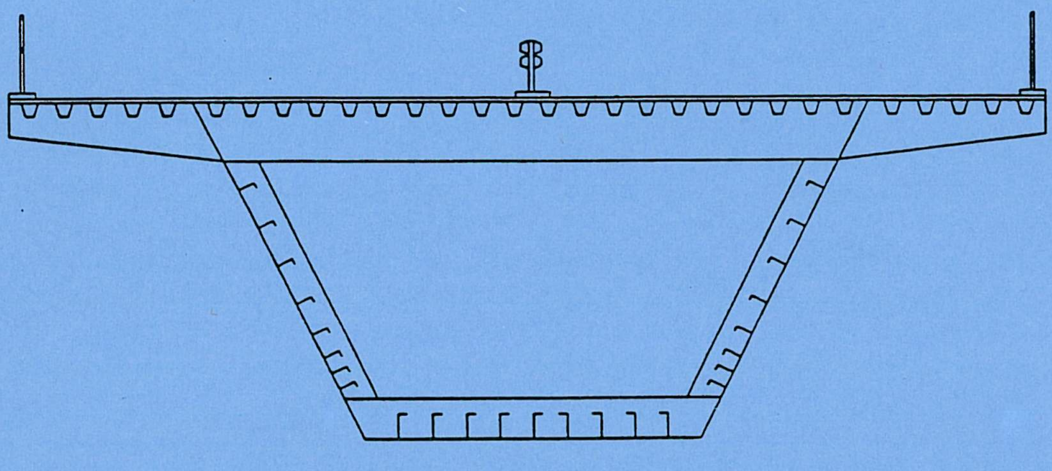


FIGURHÆFTE

STORE STÅLBROER - Bjælkebroer samt skråstags- og hængebroer
ESDEP-UDDRAG v/A. ALBERTSEN
AUGUST 1994
ISSN 0902-8005 U9408

Dette hæfte knytter sig til **NOTE U9407**, der er et teksthæfte med samme titel.

INDHOLDSFORTEGNELSE

Aalborg Universitets Trykkeri

LECTURE 15B.1
Conceptual Choice

LECTURES

FIGURES

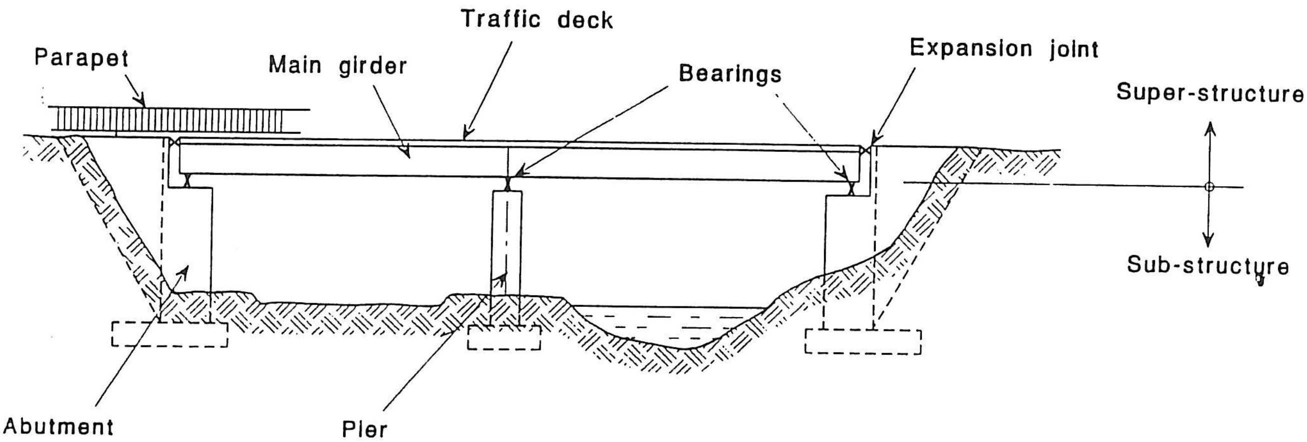


Figure 1 Elevation of typical girder bridge

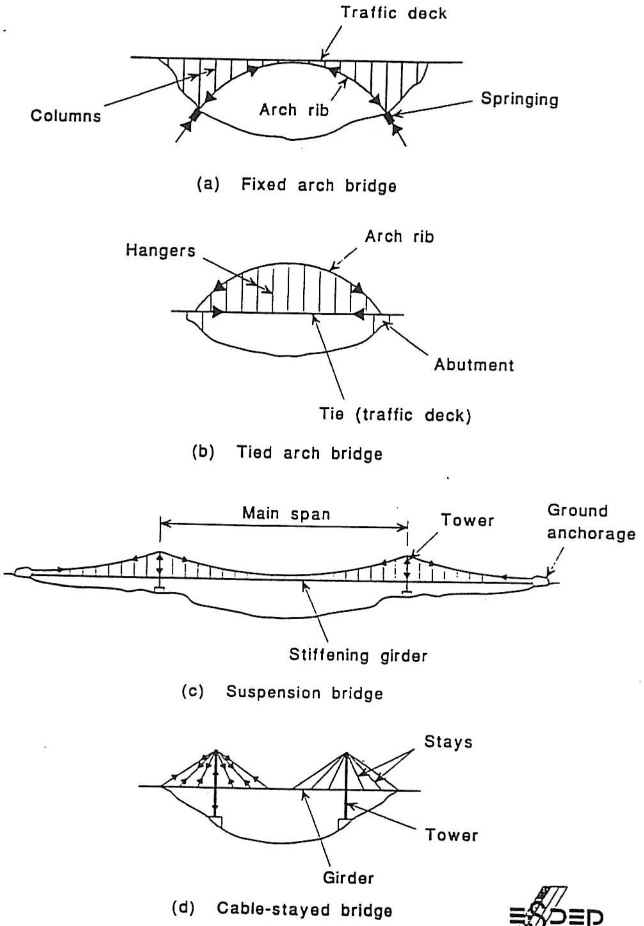


Figure 2 Types of bridge that carry load mainly by axial forces.

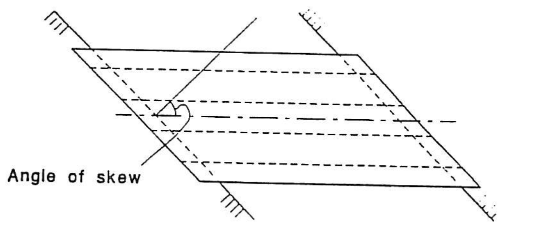


Figure 3 Typical plan view of skew bridge

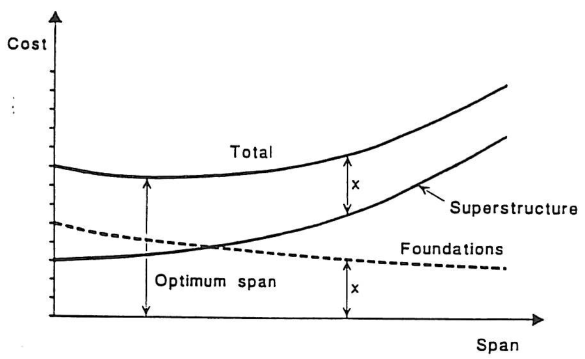


Figure 4 Bridge costs (diagrammatic)

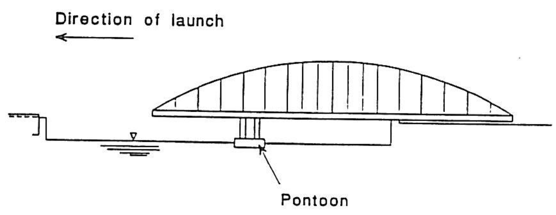


Figure 5 Typical launching arrangement using pontoon

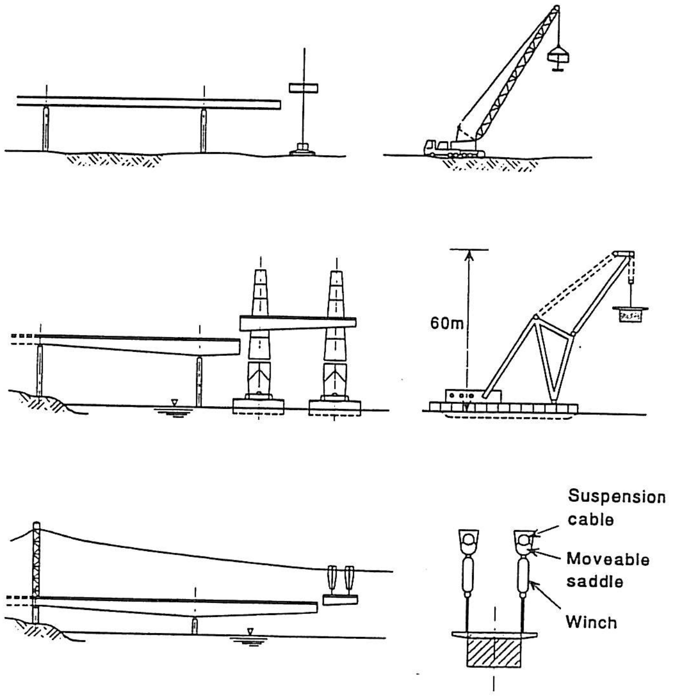


Figure 6 Typical methods of lifting bridge sections

Lecture 15B.1

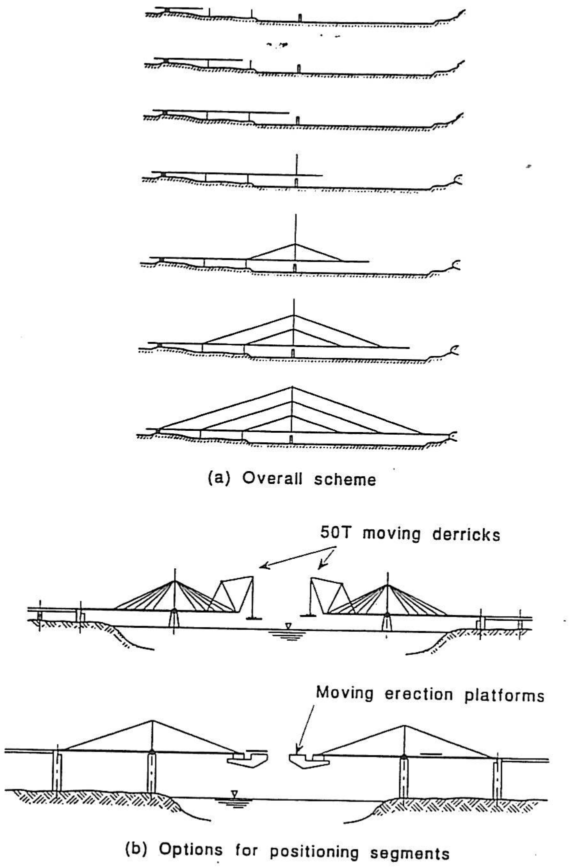


Figure 7 Typical cantilever erection of a cable-stayed bridge.

Lecture 15B.1

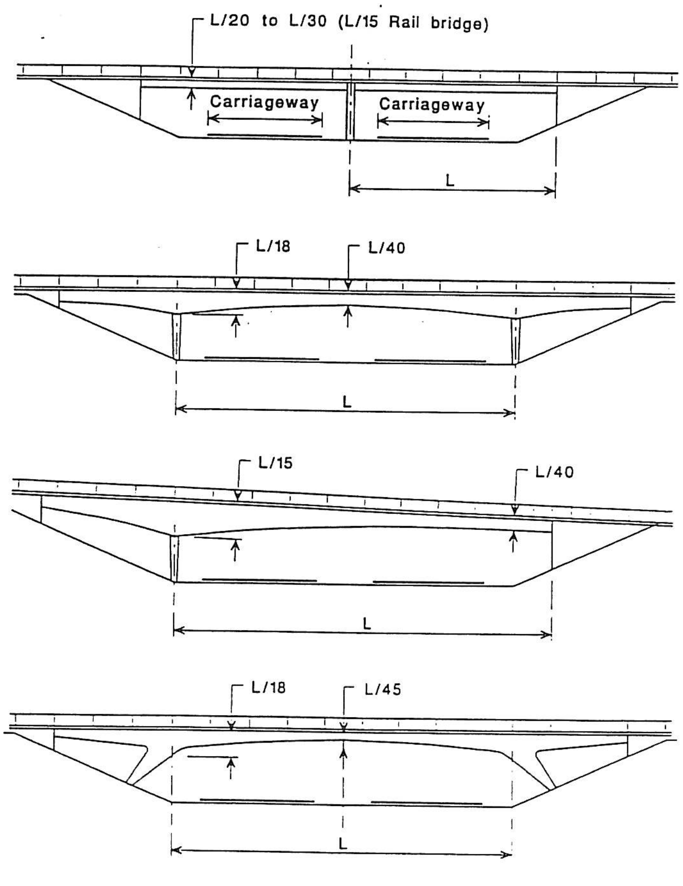


Figure 8 Typical elevations of highway overbridges.

Lecture 15B.1

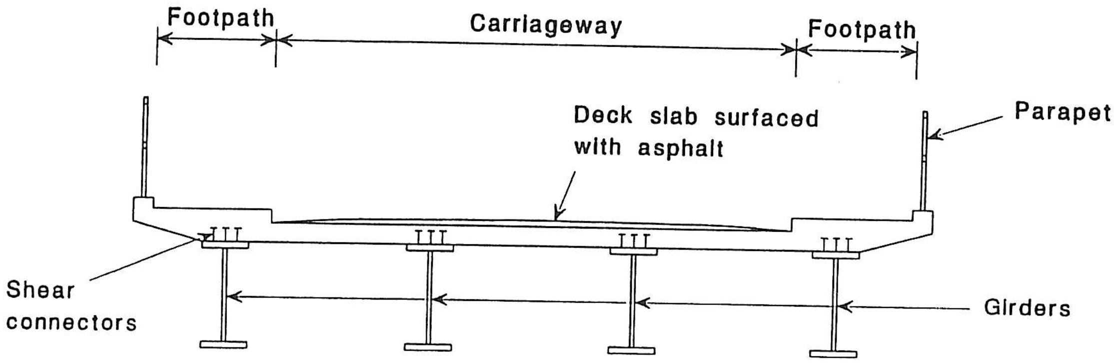


Figure 9 Typical cross-section of a single carriageway highway bridge

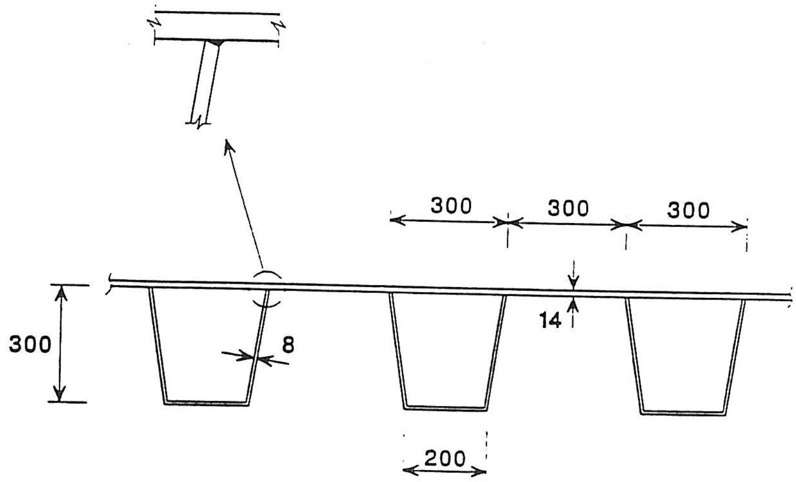


Figure 10 Orthotropic steel deck.

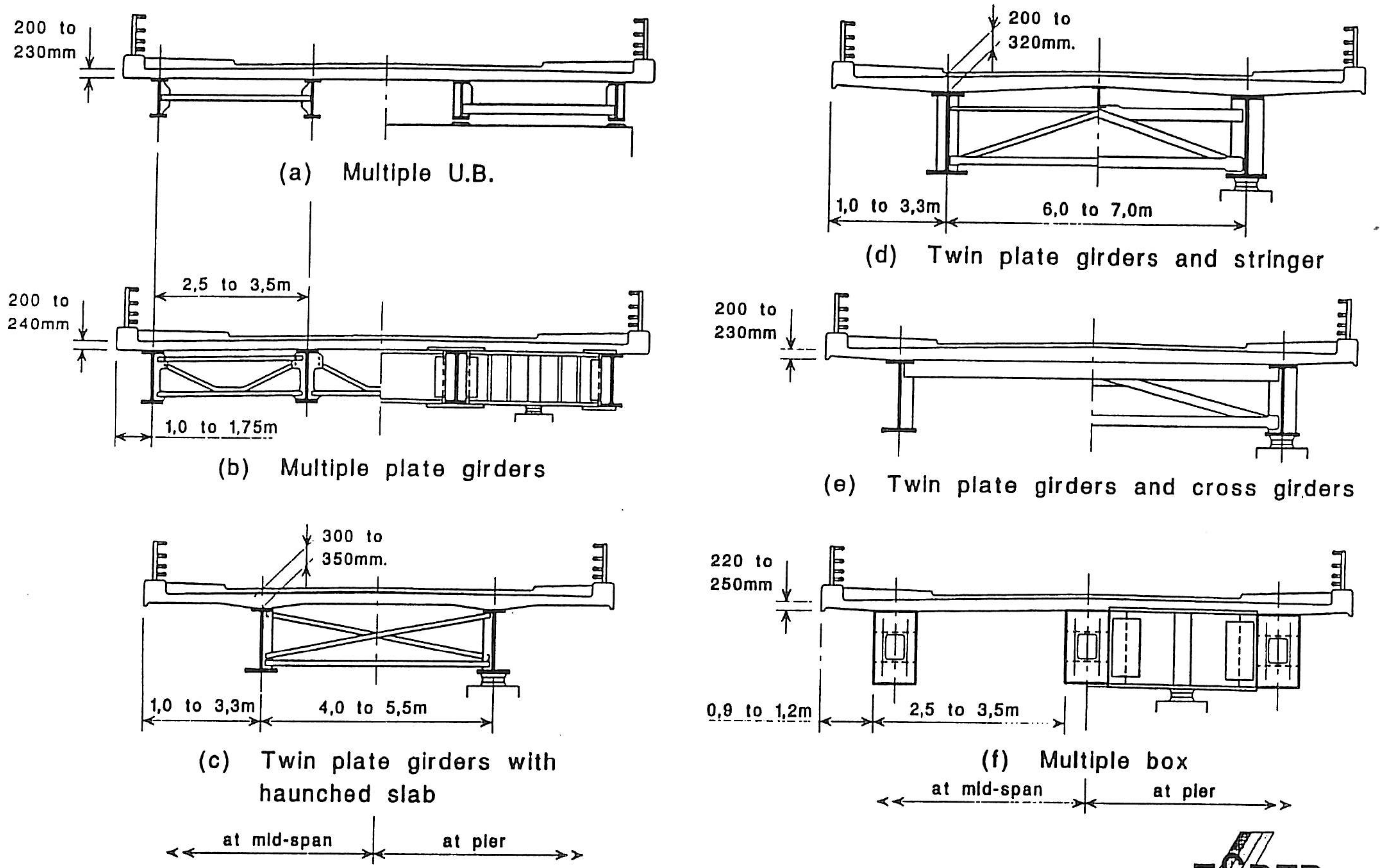


Figure 11 Typical cross-sections for highway bridges.

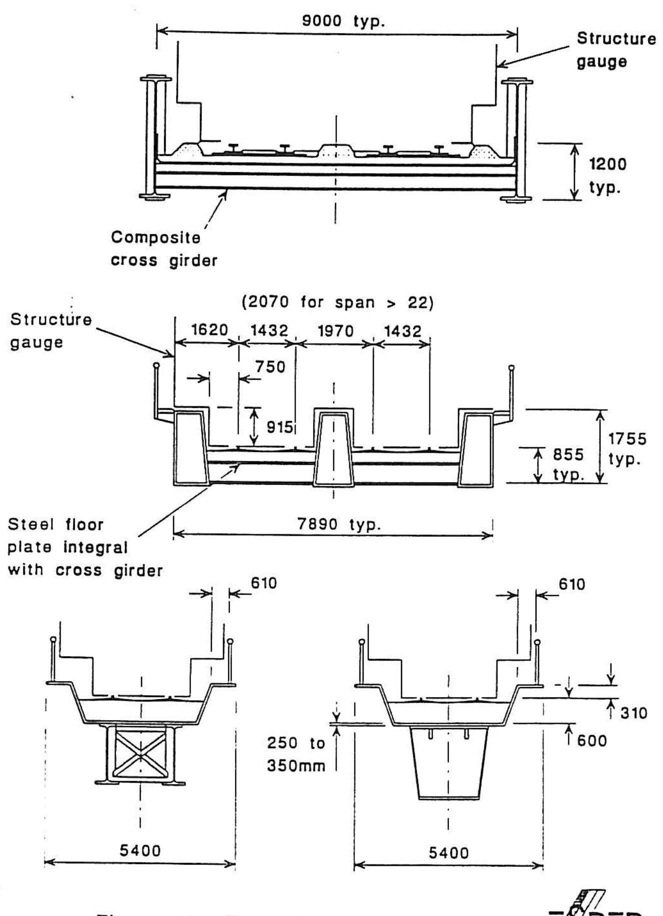


Figure 12 Typical cross-sections for railway bridges

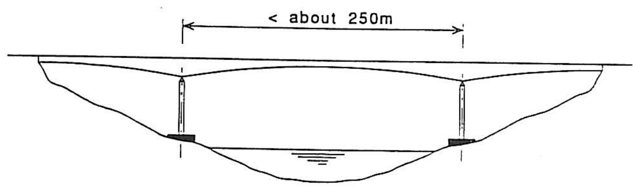


Figure 13 Typical elevation of long span girder bridge

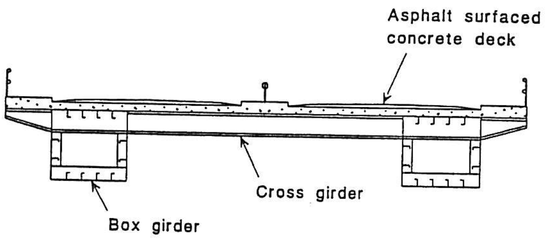


Figure 14 Typical cross-section of wide, long span, girder bridge.

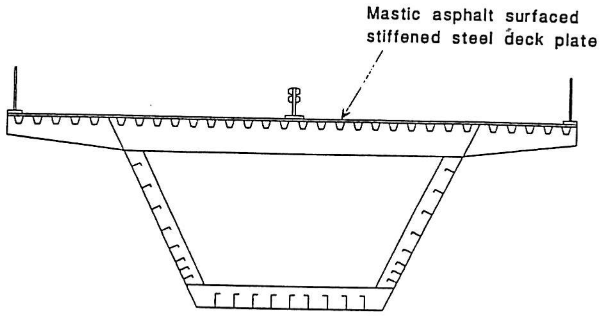


Figure 15 Typical cross-section of box girder long span bridge

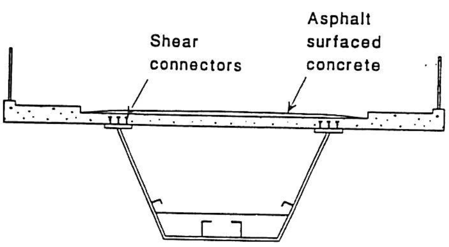


Figure 16 Typical open top composite box-girder bridge

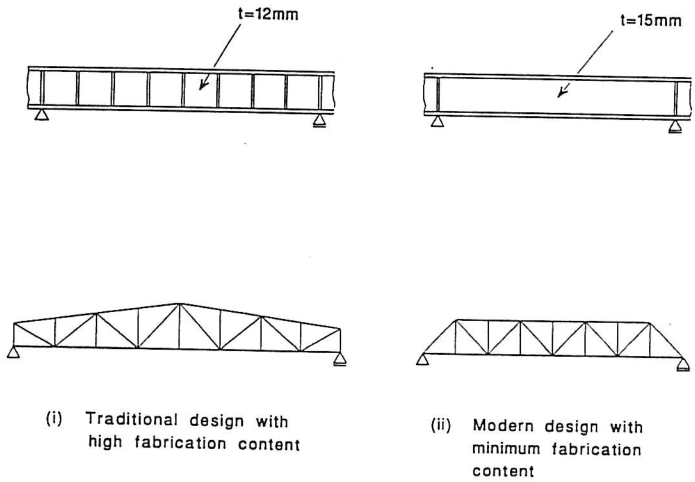


Figure 17 Changes in economic design

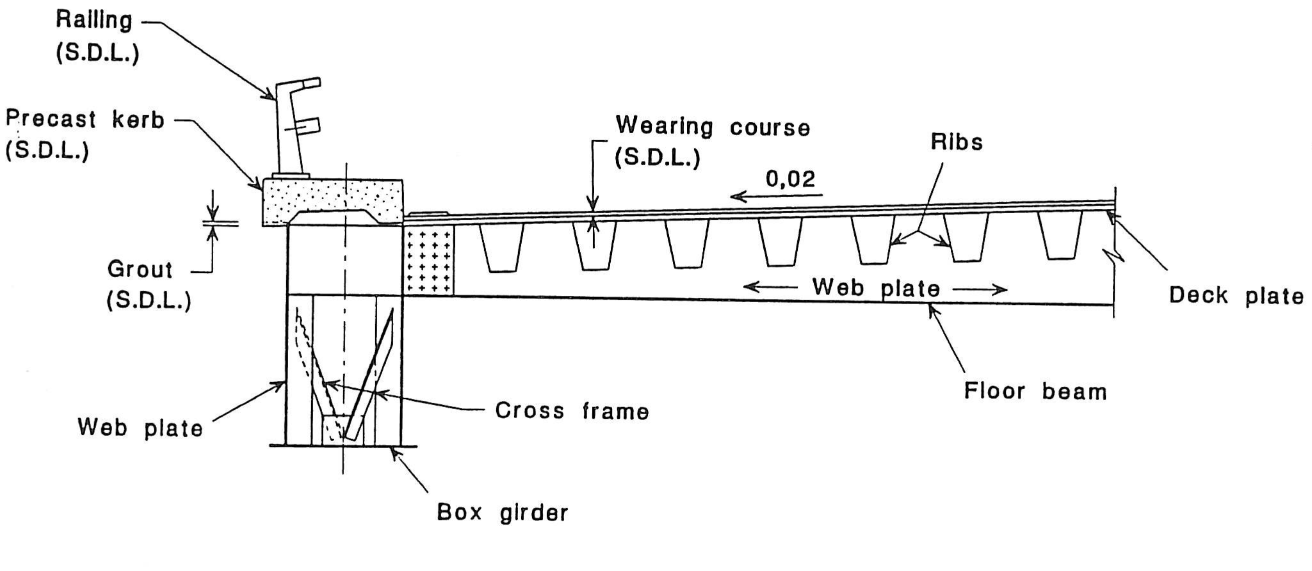


Figure 1 Dead load and superimposed dead load (S.D.L.)

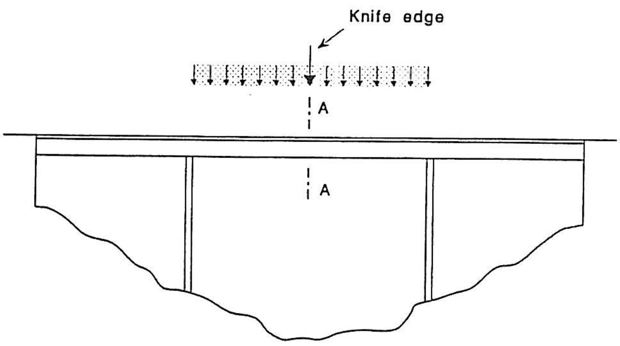


Figure 2 Location of distributed and knife edge loads to produce maximum mid-span moment.

Lecture 15B.2

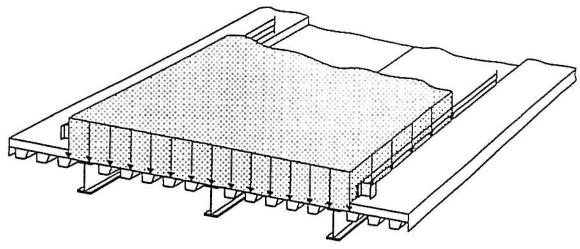
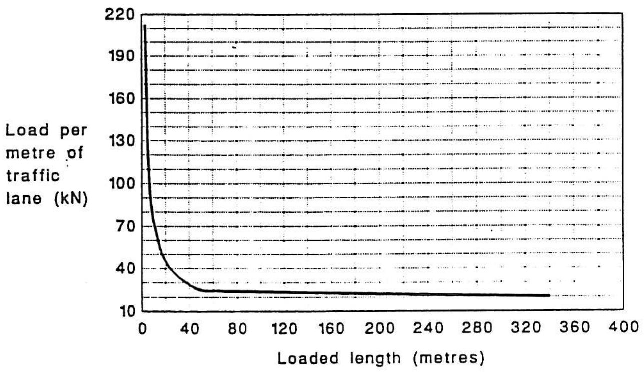


Figure 3 Uniformly distributed load on traffic lanes.

Lecture 15B.2



Note: HA loading consists of a uniformly distributed load, expressed in kN per linear metre of traffic lane and a knife edge load of 120kN applied across the width of the lane.

Figure 4 Variation of type HA loading with loaded length (U.K. Department of Transport)

Lecture 15B.2

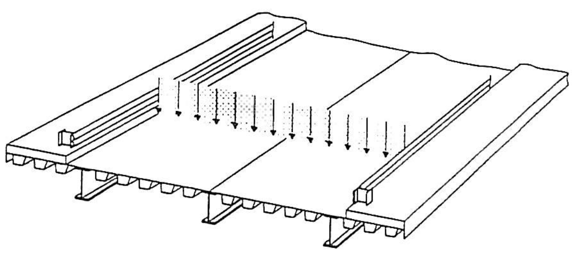


Figure 5 Knife-edge load.

Lecture 15B 2

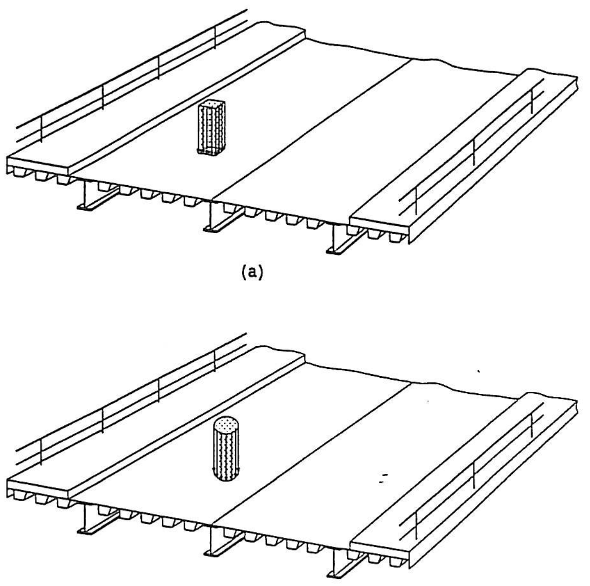


Figure 6 Single wheel loads

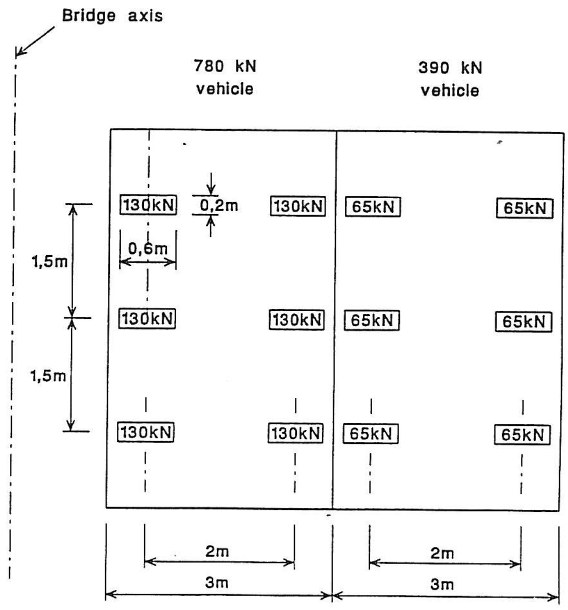


Figure 7 Concentrated wheel loads on bridge decks, according to load specifications by the Danish Road Directorate.

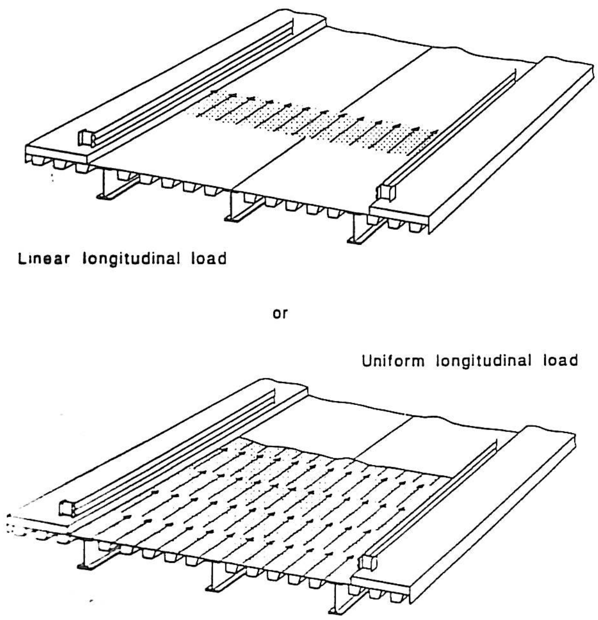


Figure 8 Longitudinal tractive forces.

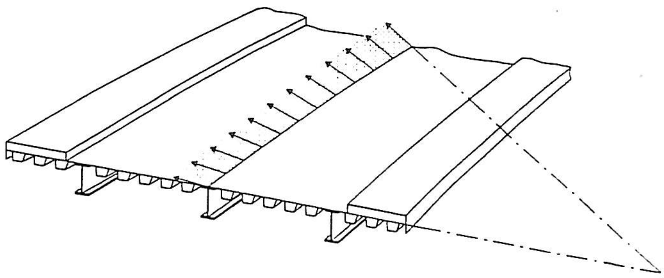


Figure 9 Centrifugal forces.

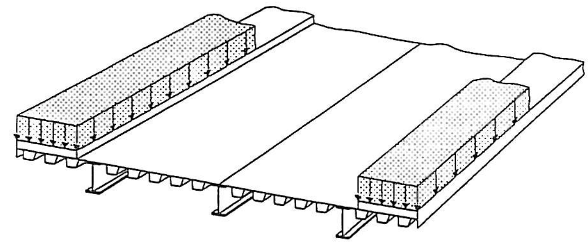


Figure 10 Sidewalk distributed load.

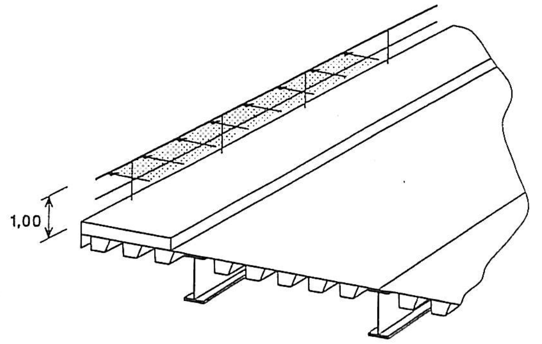


Figure 11 Distributed load on parapet.

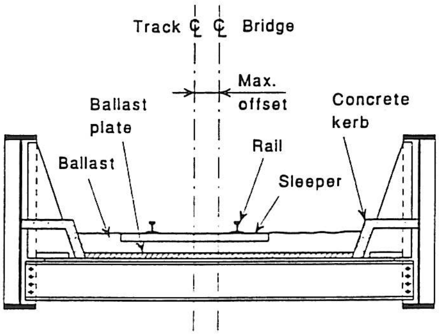


Figure 12 Typical section of a through-girder railroad bridge (curved track)

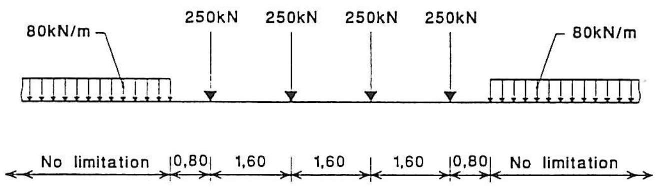


Figure 13 Typical train load.

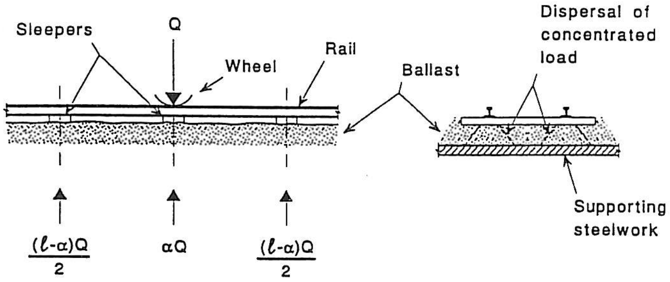


Figure 14 Dispersal of wheel loads.

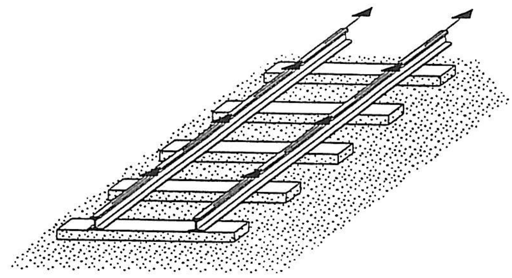


Figure 15 Longitudinal tractive forces.

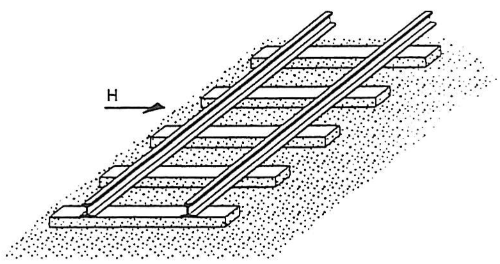


Figure 16 Horizontal force due to nosing

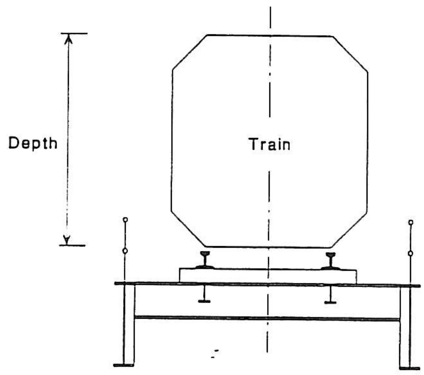


Figure 17 Depth of exposed area for wind actions.

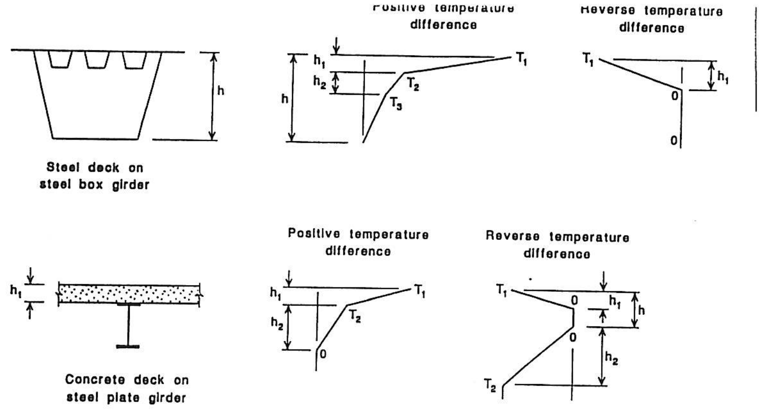
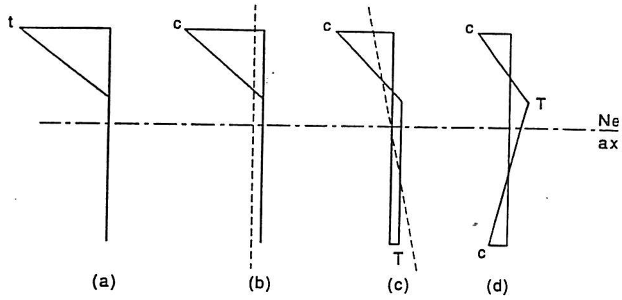


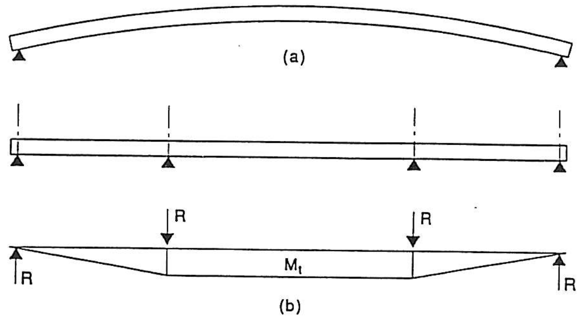
Figure 18 Examples of temperature differences.

Lecture 15B.2



a) Non-linear temperature distribution.
b) Equivalent "thermal" stresses if thermal effects fully restraine
c) Thermal stress distribution if axial restraint removed.
d) Thermal stress distribution if curvature restraint also removec

(i) Primary thermal stresses.



a) Curved shape of simply supported beam.
b) Secondary moments and reactions in beam continuous over four supports.

ii) Secondary thermal effects.

Figure 19. Structural effects of non-linear temperature distributions.

Lecture 15I

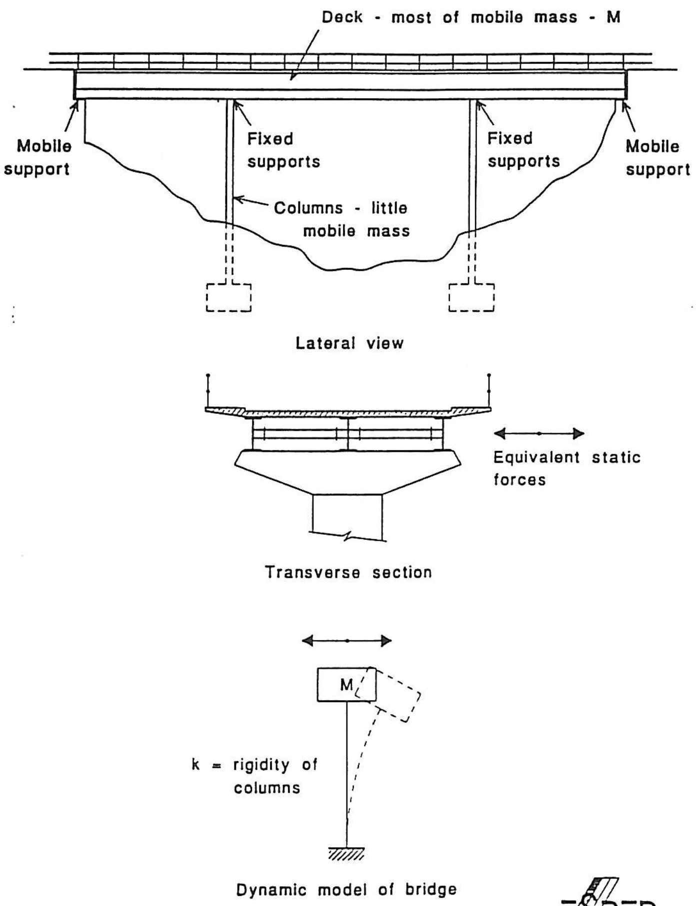


Figure 20 Example of bridge with simple dynamic behaviour.

Lecture 15B.2

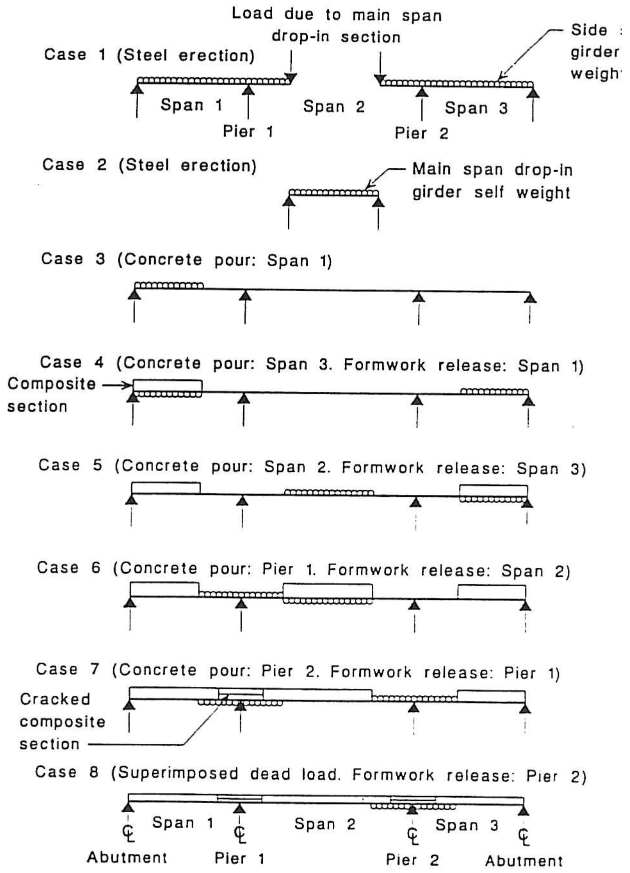


Figure 21 Construction load cases for a three-span composite highway bridge.

Lecture 15

LECTURE 15B.3
Bridge Decks

FIGURES

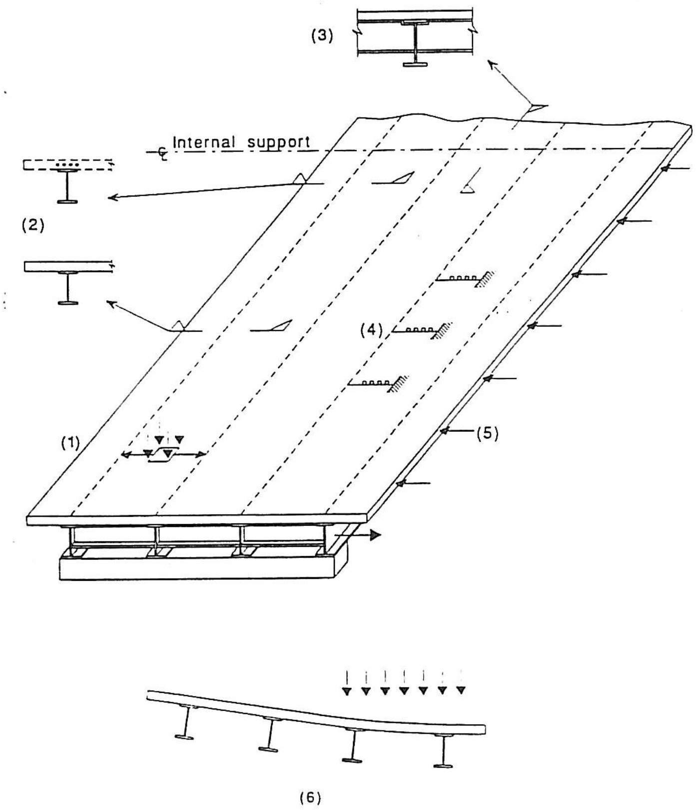


Figure 1 Structural actions of a highway bridge deck.

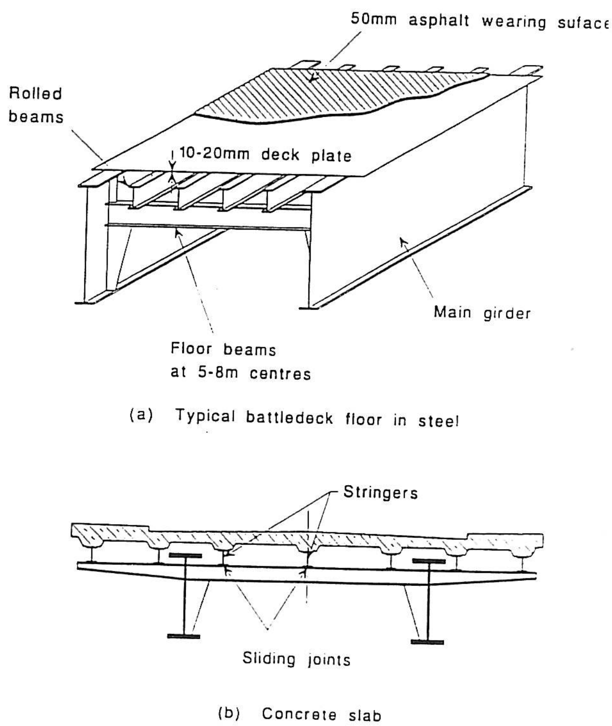
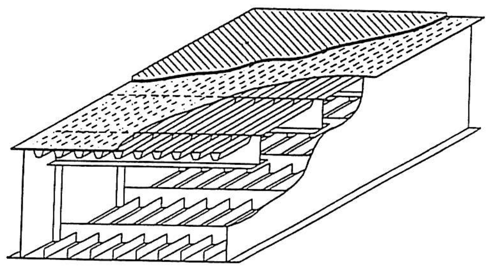
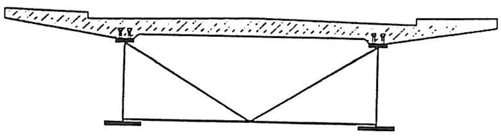


Figure 2 Early highway bridge decks.



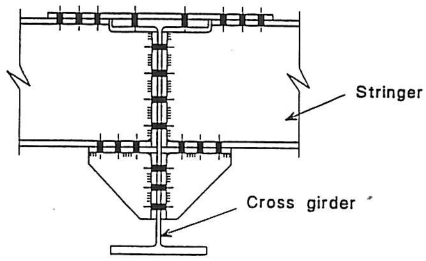
(a) Orthotropic steel deck



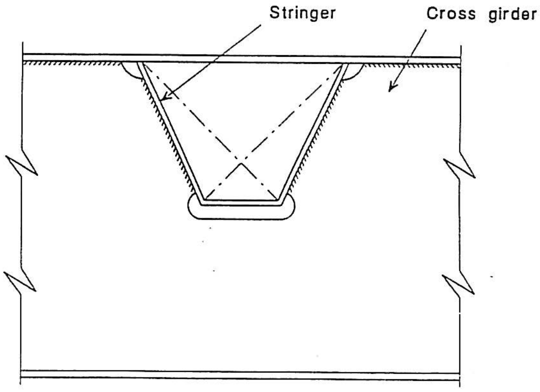
(b) Composite slab

Figure 3 Modern highway bridge decks.

Lecture 15B.3



(a) Early bolted or riveted construction

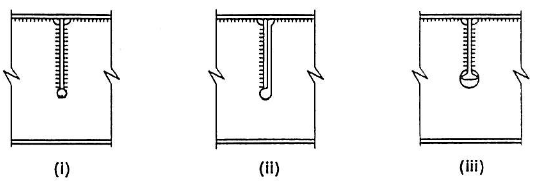


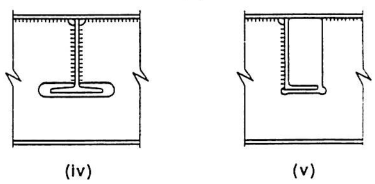
(b) Modern welded construction

Note:- Different orientation of diagrams to illustrate connections

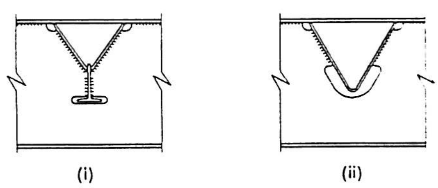
Figure 4 Stringer / Cross girder intersections

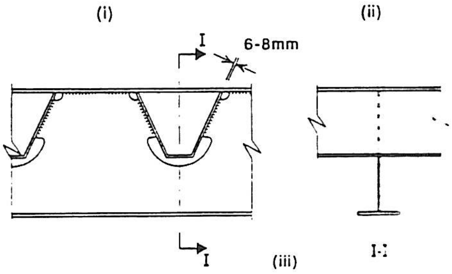
Lecture 15B.3





(a) Open, torsionally weak stiffeners

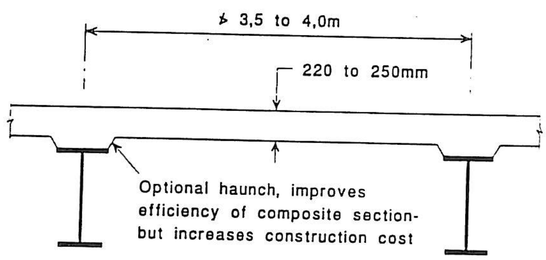




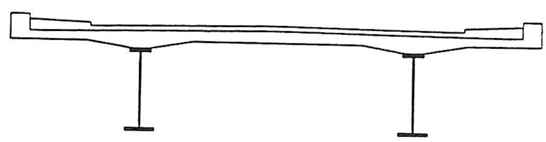
(b) Closed, torsionally stiff stiffeners

Figure 5 Stiffeners (stringers) for orthotropic steel decks

Lecture 15B 3



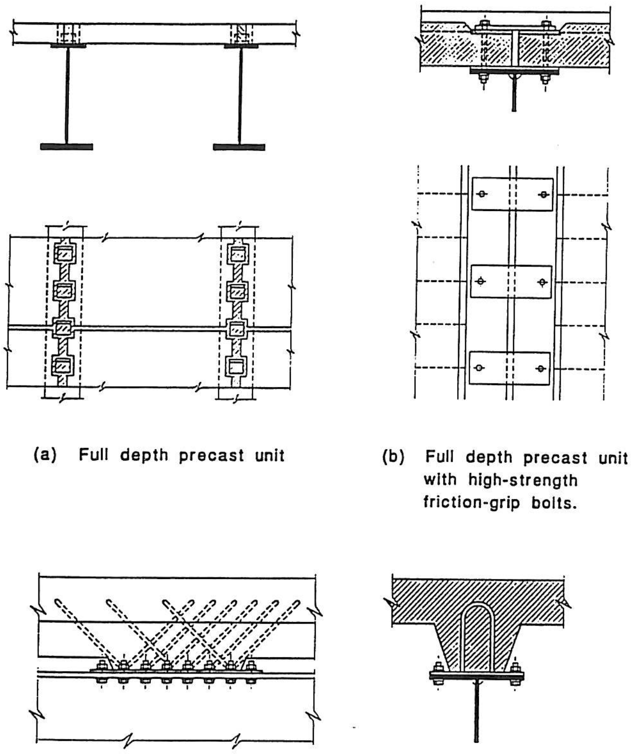
(a) Multi girder or cross girder bridge



(b) Twin girder bridge without cross girders

Figure 6 Typical proportions for reinforced concrete highway bridge decks.

Lecture 15B 3



(a) Full depth precast unit

(b) Full depth precast unit with high-strength friction-grip bolts.

(c) Full depth precast unit with high-strength friction-grip bolts

Figure 7 Means of eliminating conventional formwork for reinforced concrete decks.

Lecture 15B.3

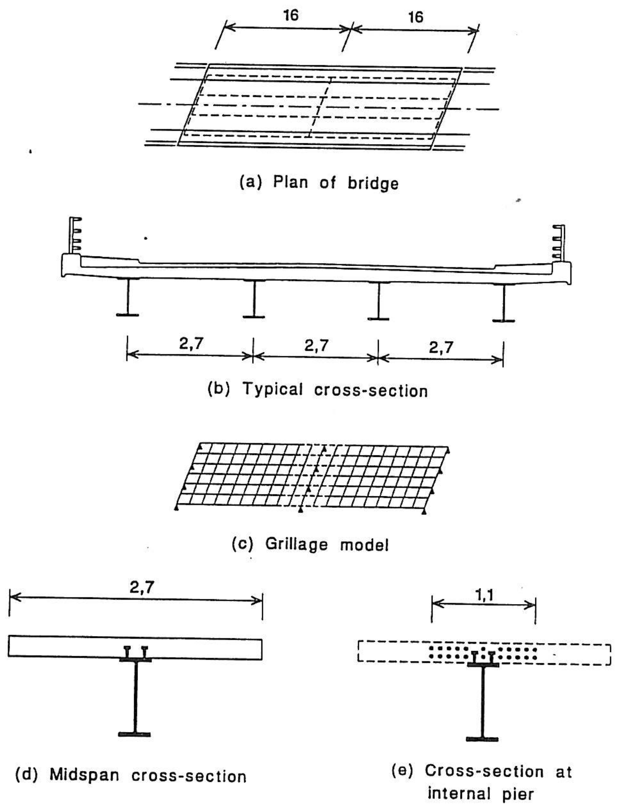


Figure 8 Typical grillage analysis for composite bridge, demonstrating the modelling of the slab as equivalent beam strips.

Lecture 15B.3

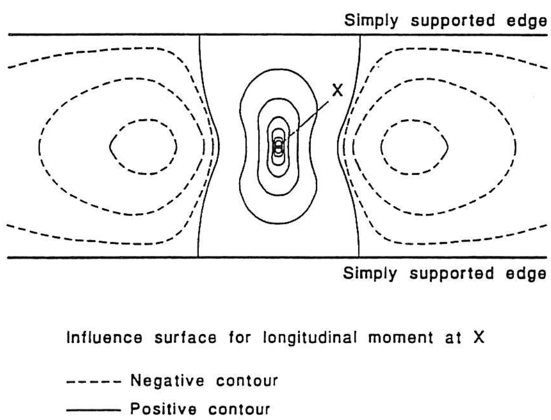


Figure 9 Example of Puchers charts for determining slab moments from local wheel loads.

Lecture 15B.3

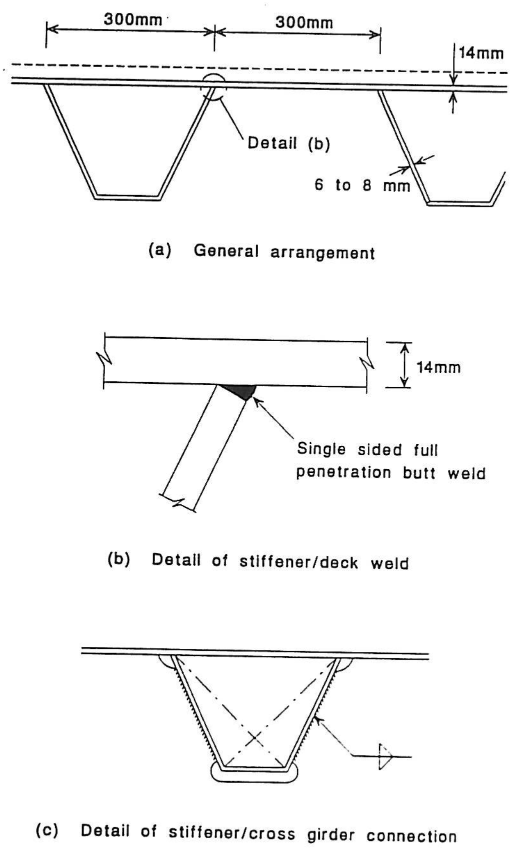


Figure 10 Standard orthotropic deck.

Lecture 15B.3

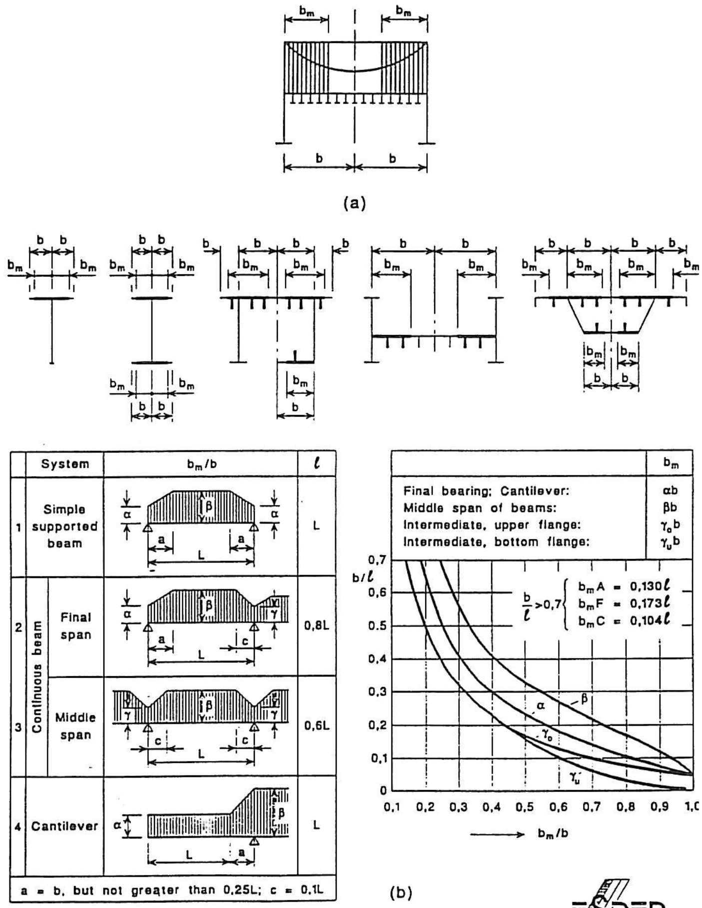


Figure 11 Definition of the effective width b_m

ESDEP

Lecture 15B.3

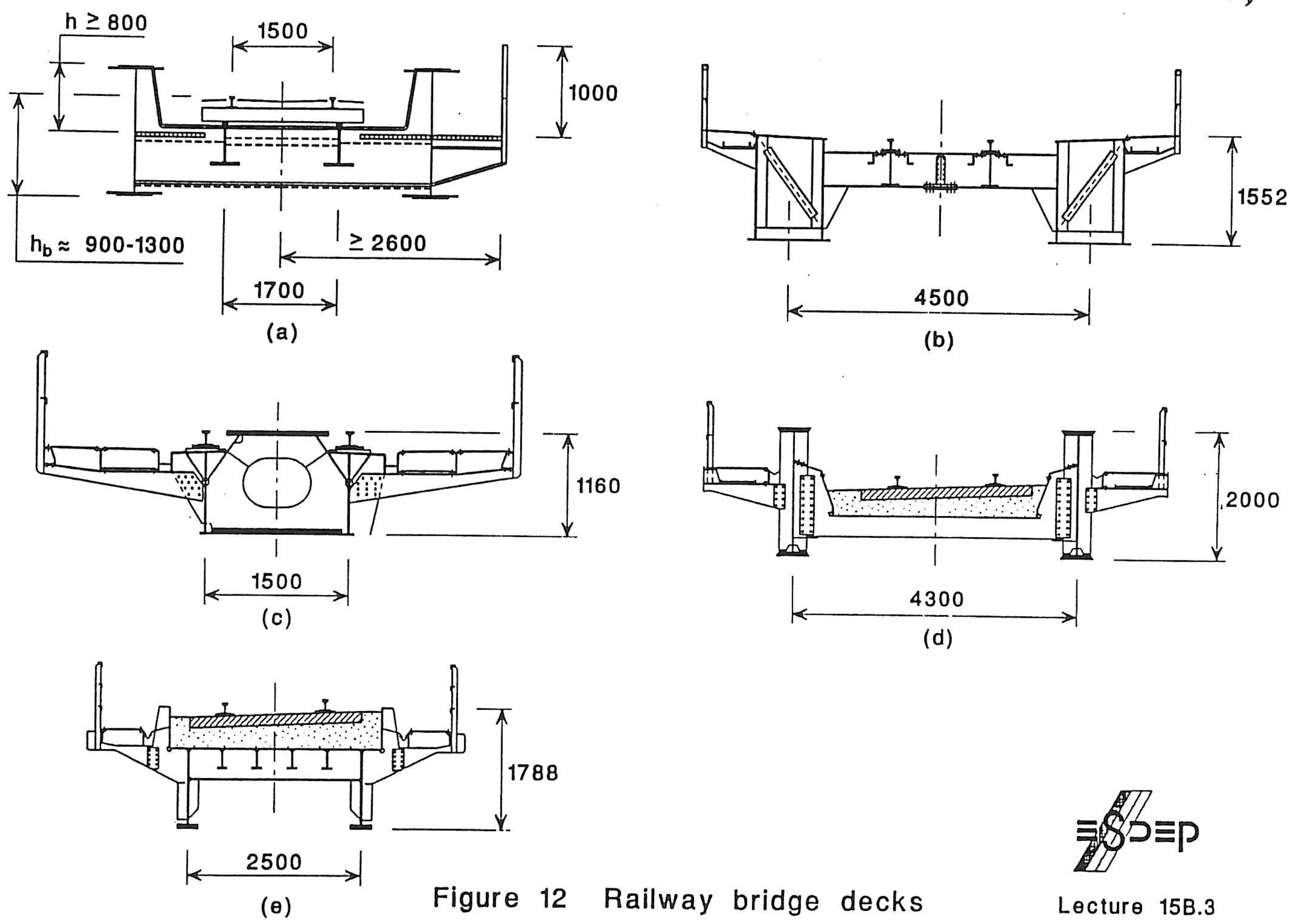


Figure 12 Railway bridge decks

ESDEP

Lecture 15B.3

LECTURE 15B.4
Plate Girder and Beam Bridges

LECTURES

FIGURES

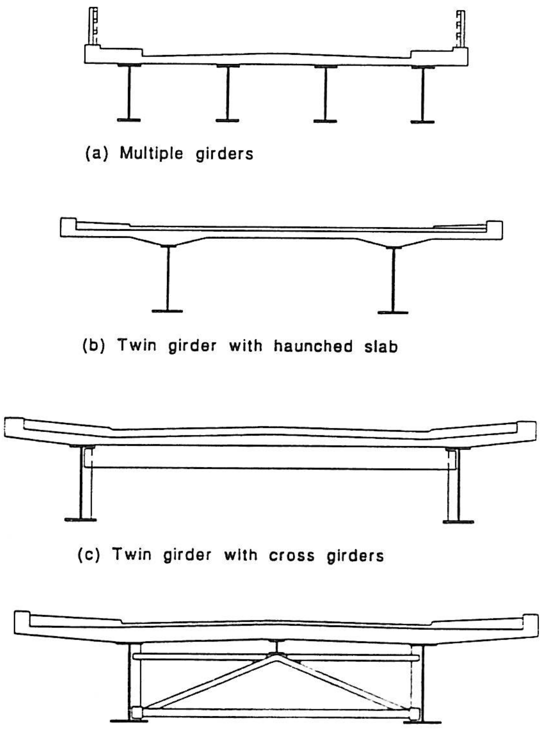


Figure 1 Types of composite plate girder and girder bridge

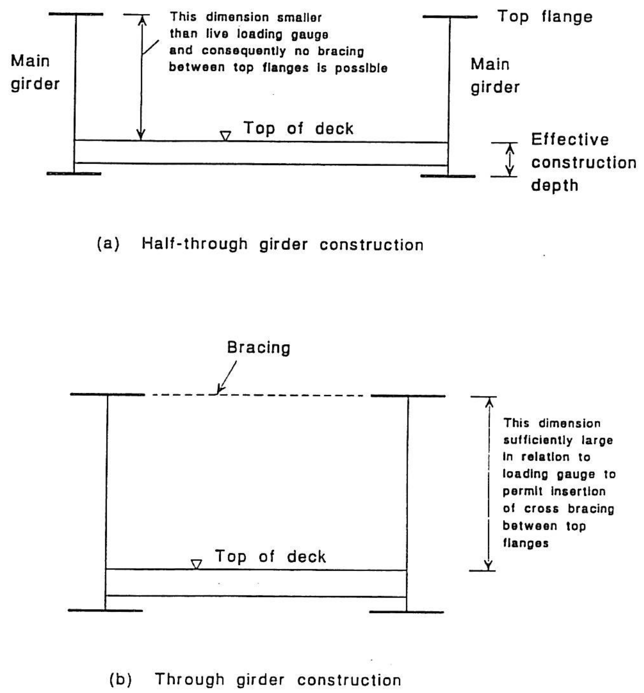
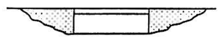
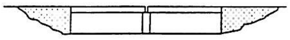


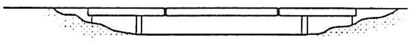
Figure 2 Half-through and through girder cross-sections.



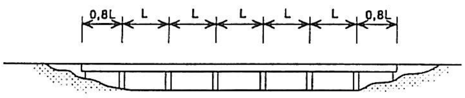
(a) Single span



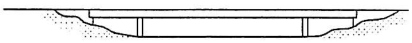
(b) Simply supported spans



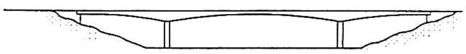
(c) Cantilever and suspended span



(d) Ideal length proportions for continuous viaduct



(e) Typical continuous motorway over-bridge



(f) Continous - curved soffit

Figure 3 Arrangments for longitudinal girders

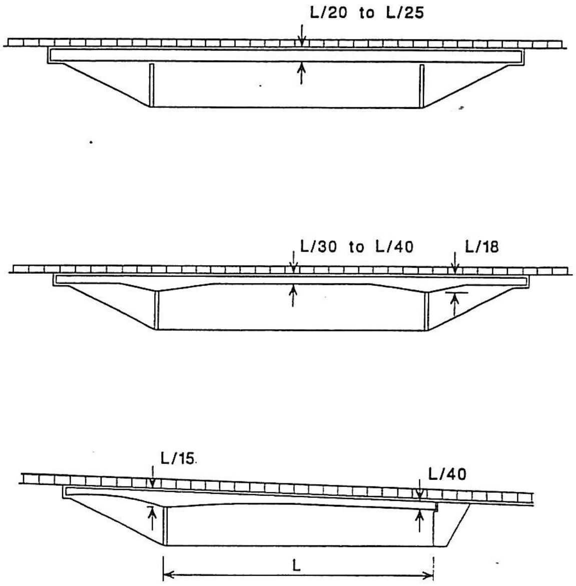
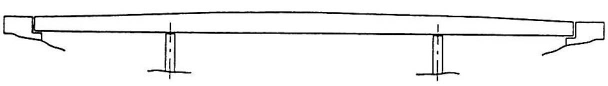


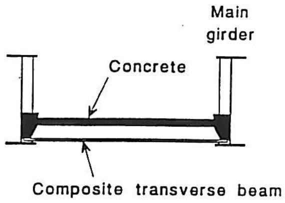
Figure 4 Typical span/depth proportions

(a) Haunched form (curved soffit)

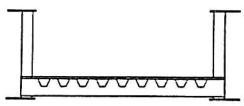


(b) Curved top flange form

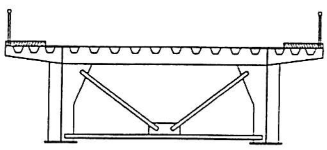
Figure 5 Alternative forms of variable depth plate girders



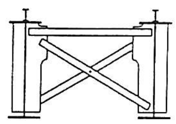
(a) Half-through arrangement with composite transverse beams



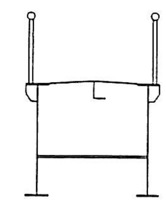
(b) Half-through arrangement with steel orthotropic deck



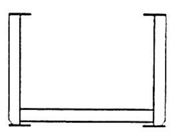
(c) Twin plate girder with steel orthotropic deck forming deck-type cross-section



(d) Twin plate girder with main girders acting as rail bearers (uncommon)



(e) Twin beam/girder footbridge cross-section



(f) Half-through arrangement for footbridge

Figure 6 Selection of plate girder/beam bridge configurations

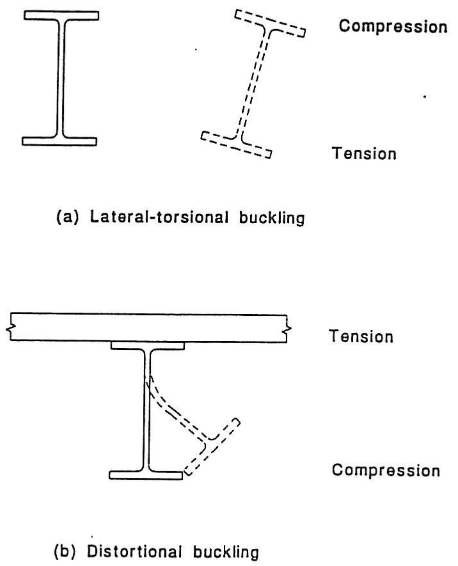


Figure 7 Modes of instability of plate girders

Lecture 15B.4

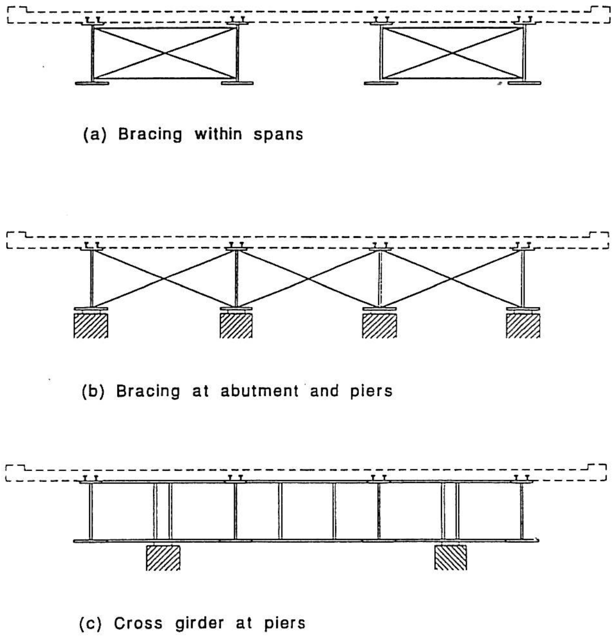


Figure 8 Types of transverse structure for composite plate girder bridges

Lecture 15B.4

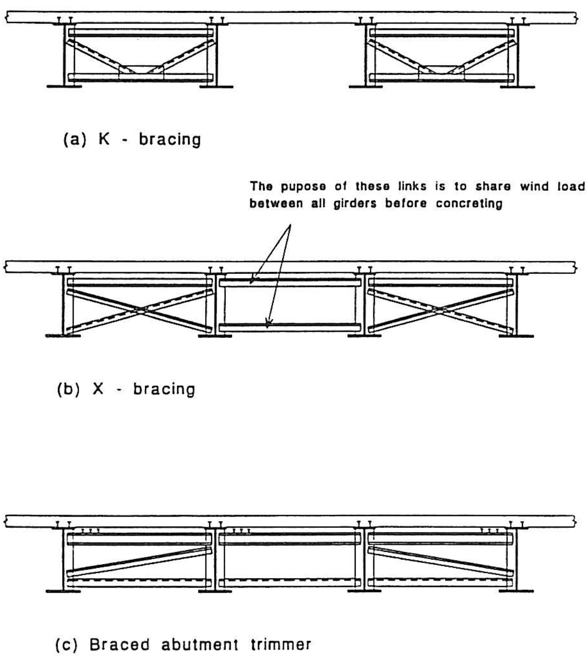


Figure 9 Commonly used bracing systems

Lecture 15B.4

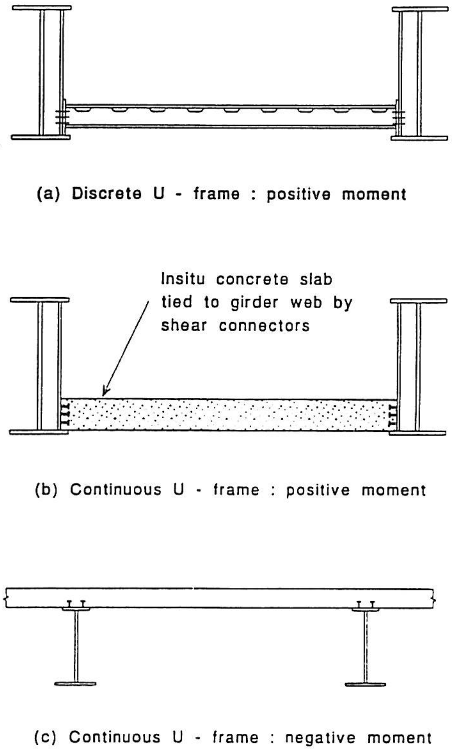
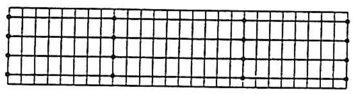
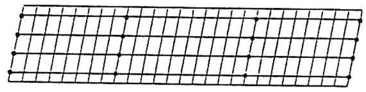


Figure 10 Types of U - frame restraint to compression flange

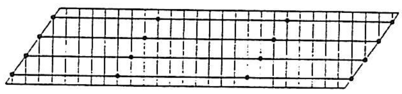
Lecture 15B.4



(a) Orthogonal grillage



(b) Grillage for spans with small skew (< 20°)



(c) Grillage for spans with large skew (> 20°)

Figure 11 Typical grillages

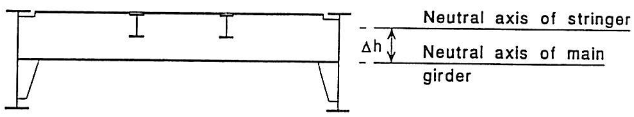
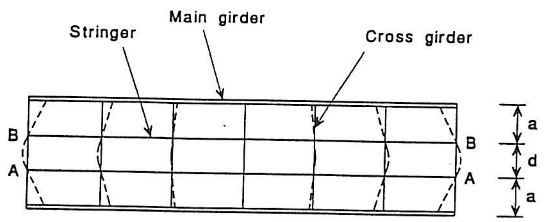
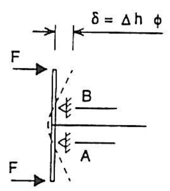


Figure 12 Open grid steel deck - difference in neutral axis levels between stringers and main girders

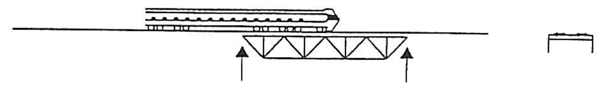


(a) Plan dimensions and deformed shape under uniformly distributed loading

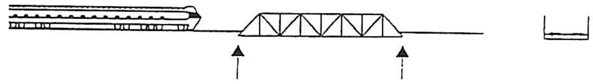


(b) End cross girder deformation

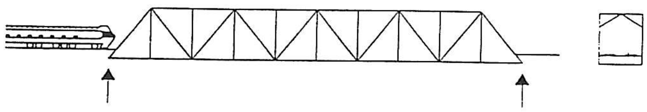
Figure 13 Open grid steel deck - layout and deformations



(a) Underslung truss



(b) Semi-through truss (U-frame)



(c) Through truss

Figure 1 Truss configurations

Lecture 15B.5

LECTURE 15B.5
Truss Bridges

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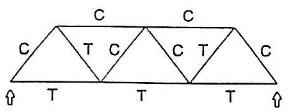
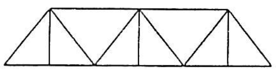
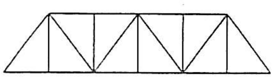
FIGURES



(a) Modern Warren truss:
spans 30-150m
T = Tension
C = Compression

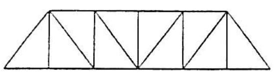


(b)

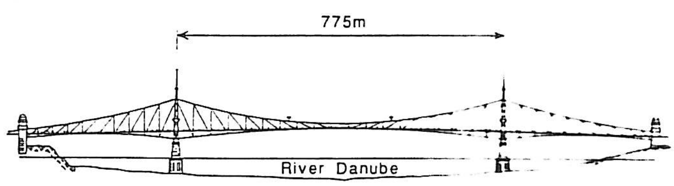


(c)

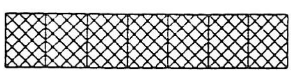
(b) and (c)
Modified Warren trusses:
spans 30-150m:
still used for railway bridges



(d) Pratt truss
spans 30-100m

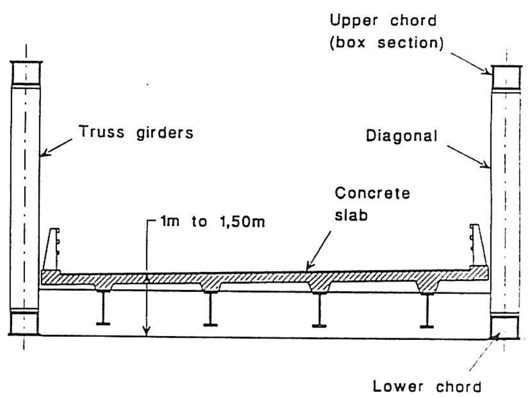


(e) Nagy truss in Budapest 1892

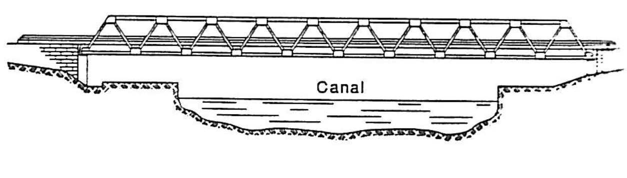


(f) Lattice truss of historical interest only

Figure 2 Principal types of truss

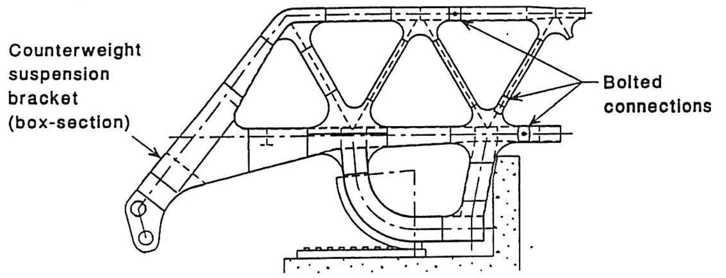


Cross-section

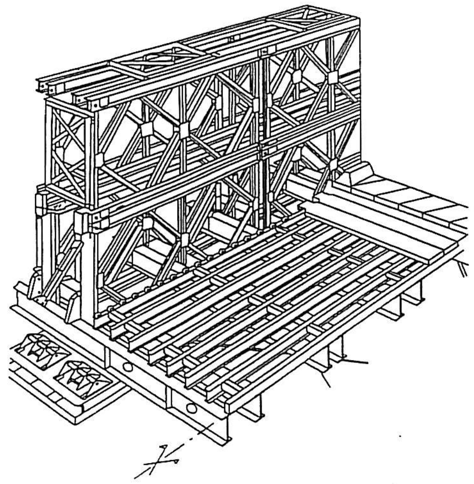


Elevation

Figure 3 A typical highway truss bridge.



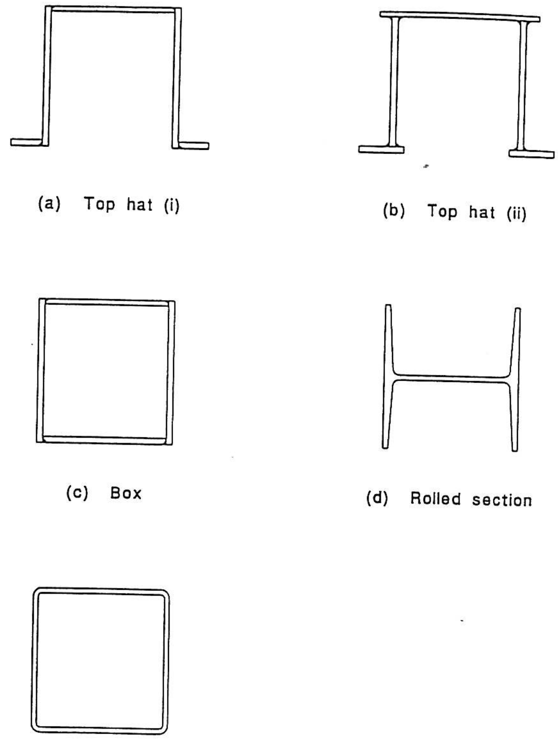
(a) Example of movable truss bridge. Rear part of the bridge.



(b) Bailey temporary bridge for emergency uses.

Figure 4 Particular applications of trusses in bridge construction

Lecture 15B.5



(a) Top hat (i)

(b) Top hat (ii)

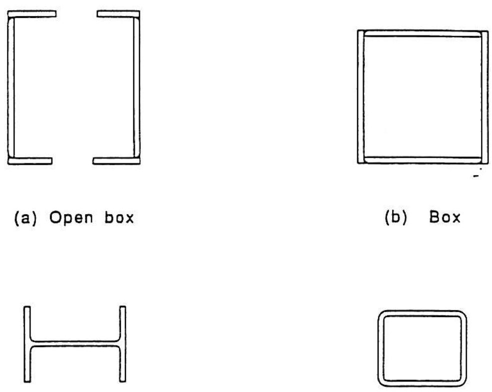
(c) Box

(d) Rolled section

(f) Rolled hollow section

Figure 5 Compression chord members

Lecture 15



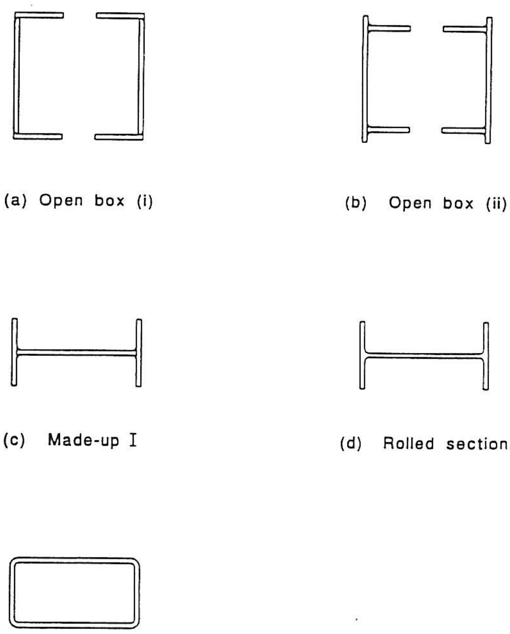
(a) Open box

(b) Box

(c) Rolled section

(d) Rolled hollow section

Figure 6 Tension chord members



(a) Open box (i)

(b) Open box (ii)

(c) Made-up I

(d) Rolled section

(e) Rolled hollow section

Figure 7 Diagonal and vertical members

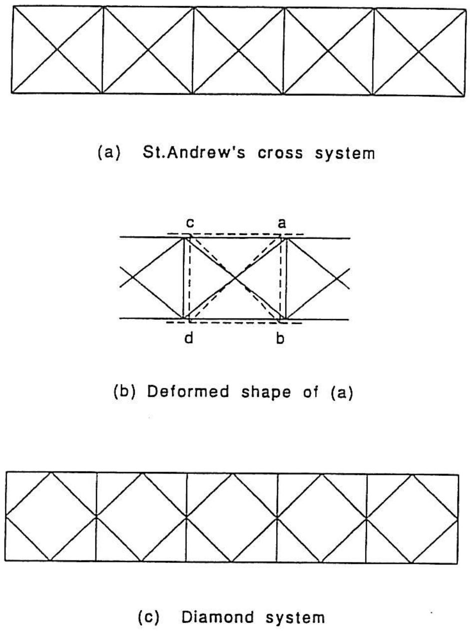
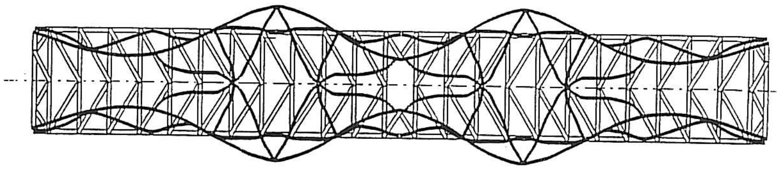


Figure 8 Upper chord lateral bracing



Plan: upper chord
Note: Truss webs, upper chord and its lateral bracing shown as solid lines for clarity

Figure 9 Buckling mode of a diamond system used as upper chord lateral bracing.

Lecture

Lecture 15B.

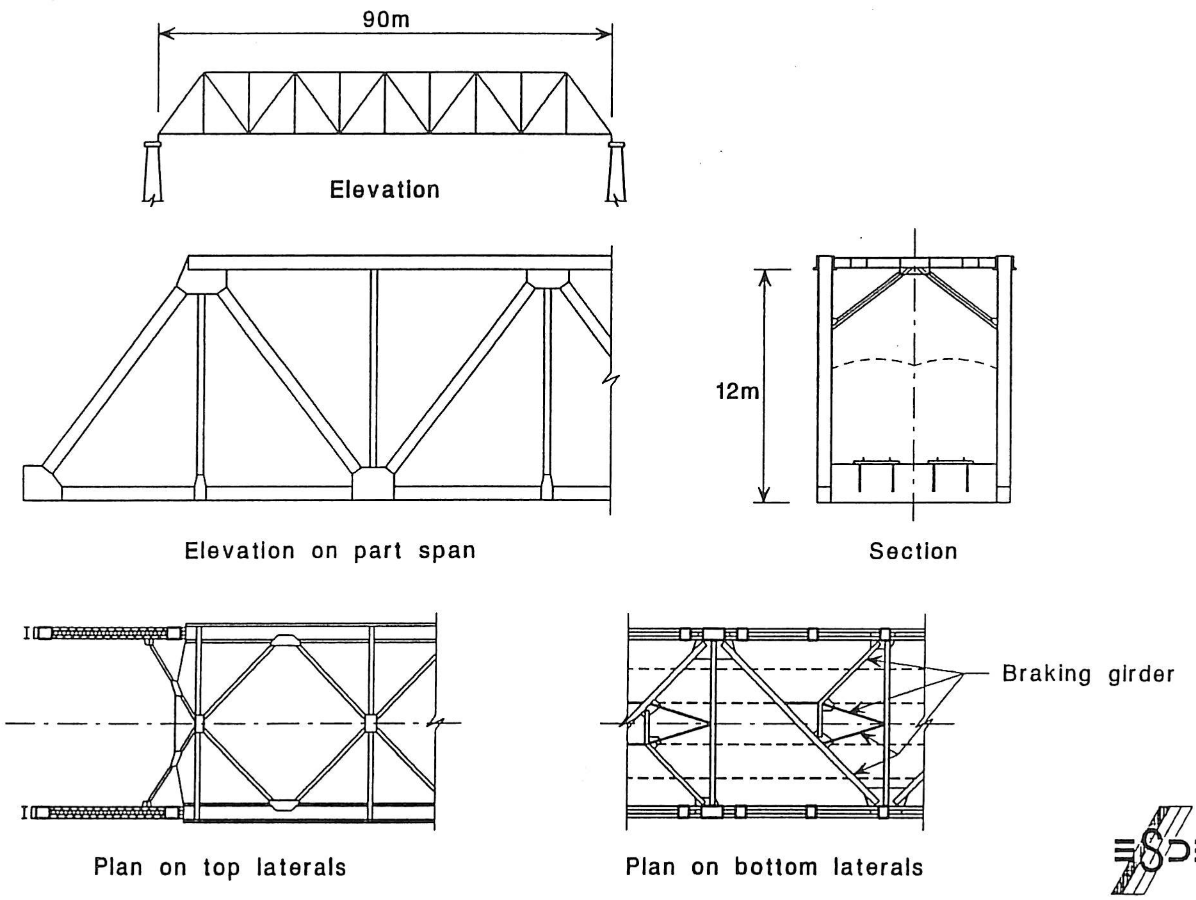


Figure 10 General arrangement of a through truss railway bridge.

Lecture 15B.5

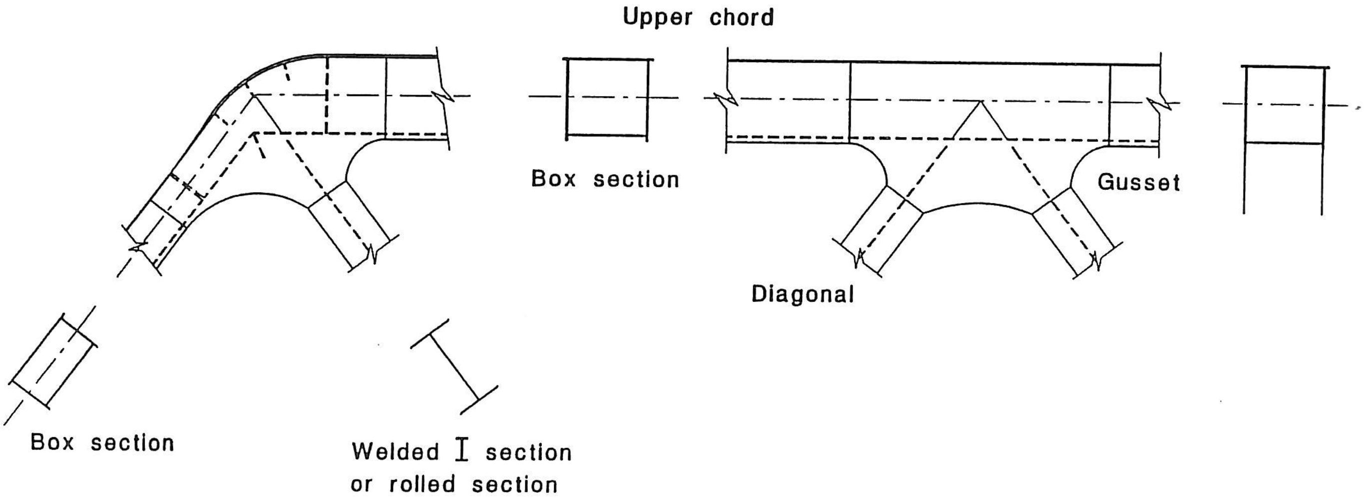


Figure 11 Butt-welded connections and gusset geometries used to avoid fatigue in the connection.

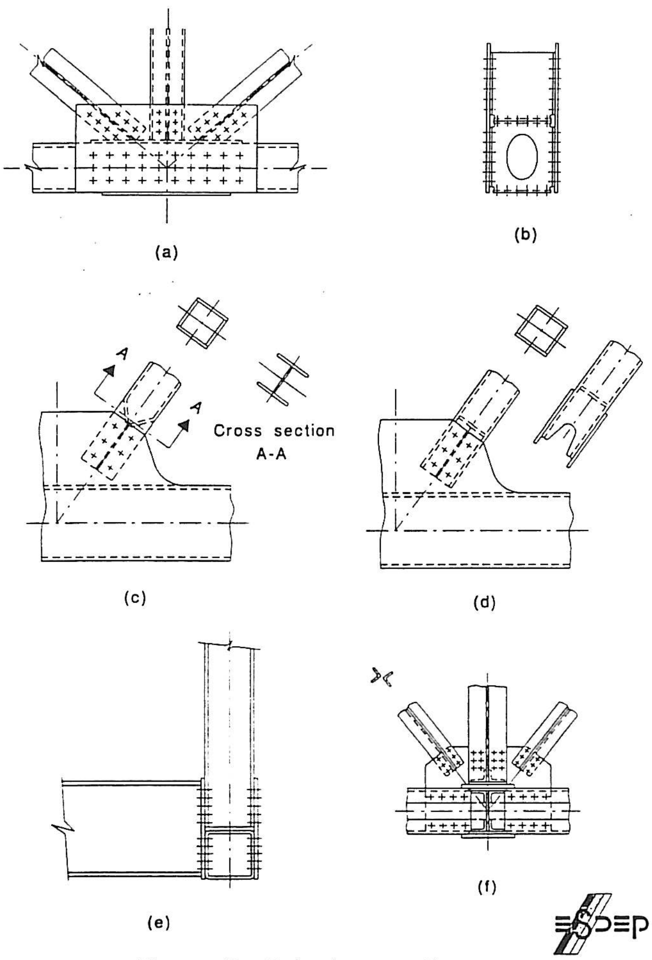


Figure 12 Bolted connections

LECTURE 15B.6
Box Girder Bridges

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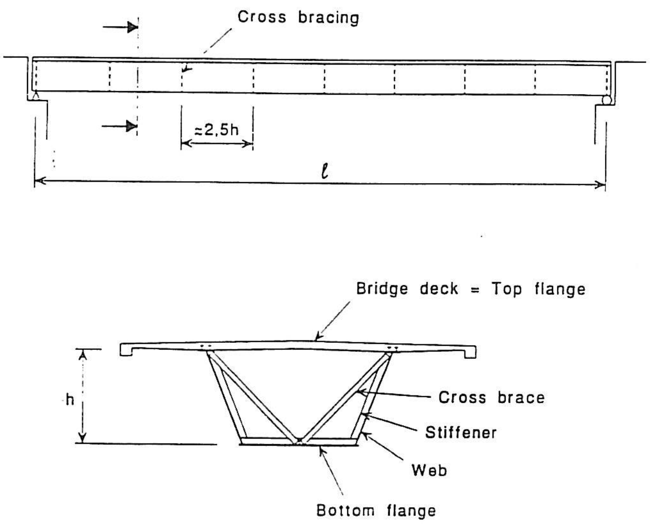


Figure 1 Box girder bridge with composite concrete deck: nomenclature

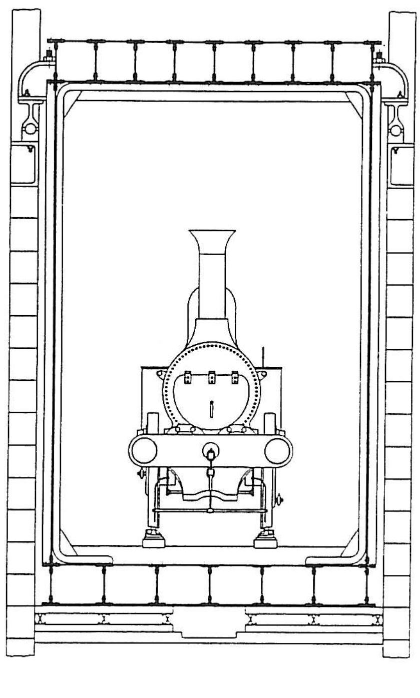


Figure 2 Britannia bridge, 1850.

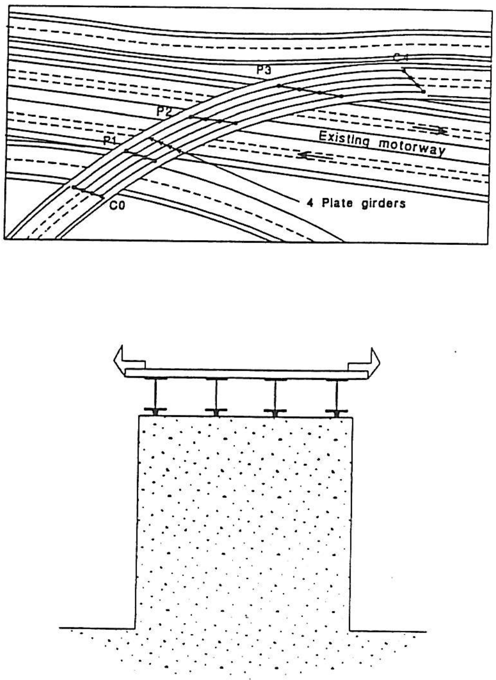


Figure 3a   Plate girder bridge.

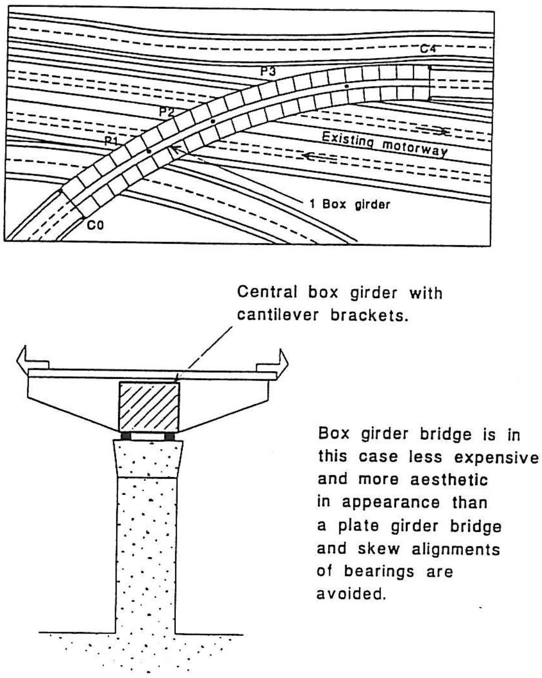


Figure 3b   Box girder bridge.

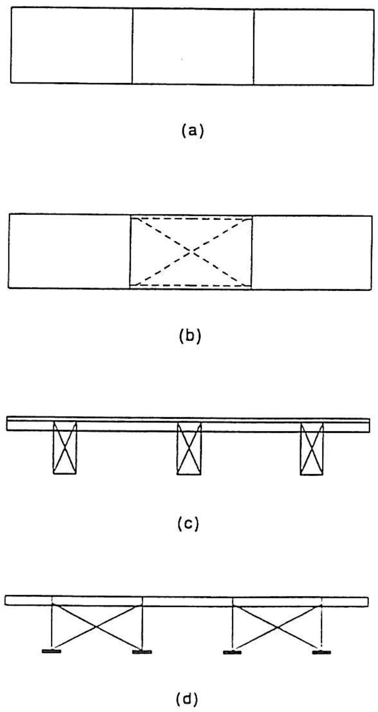


Figure 4   Types of cross-section.

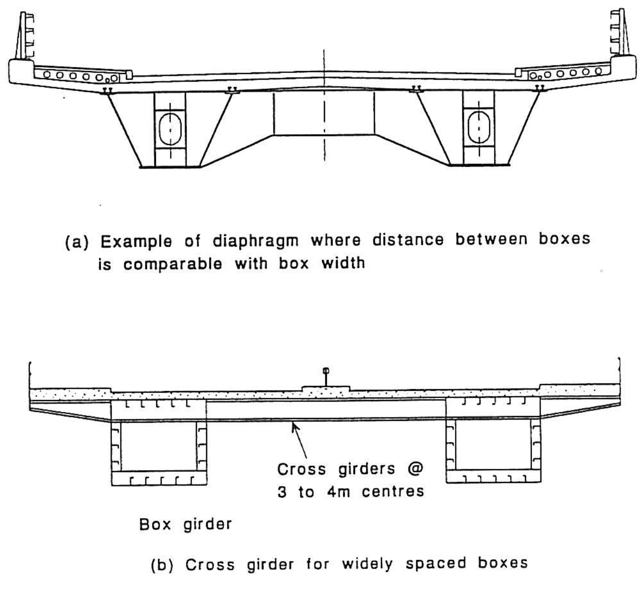


Figure 5   Intermediate transverse elements between boxes.

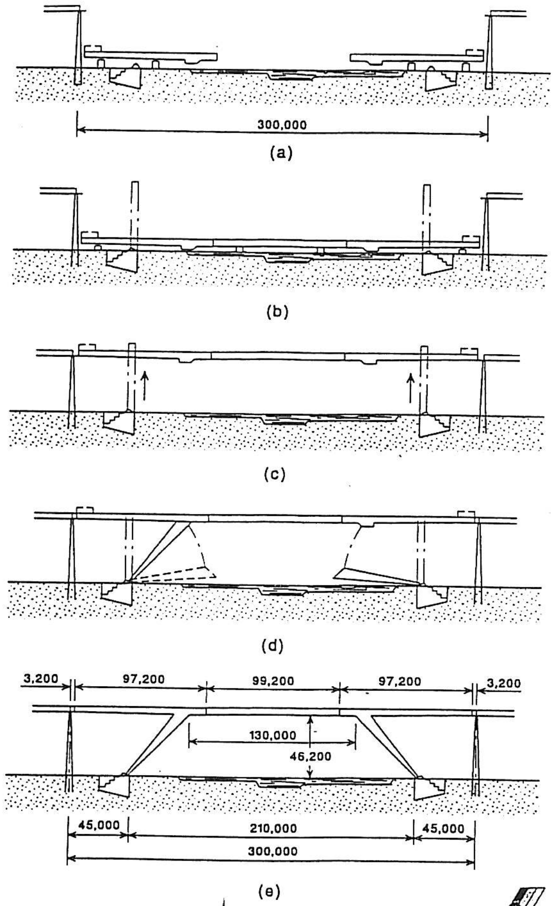
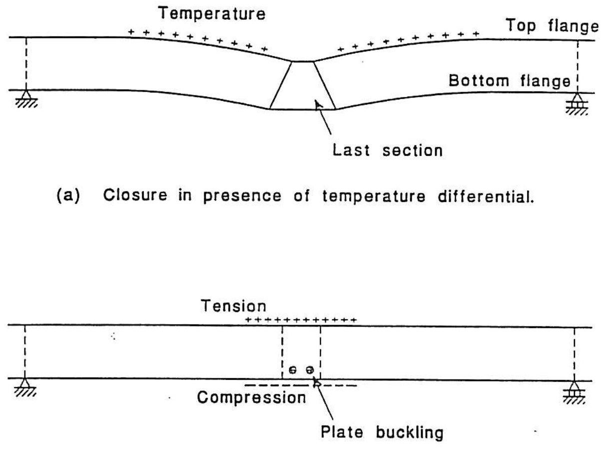


Figure 6 Erection of the Pont de Martique



(b) Condition under uniform temperature.

Figure 7 Bridge across Danube, Vienna.

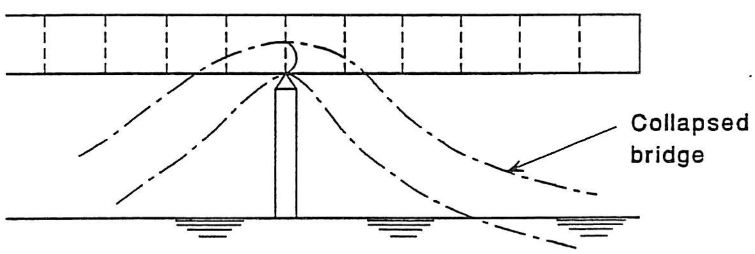


Figure 8 Milford Haven Bridge

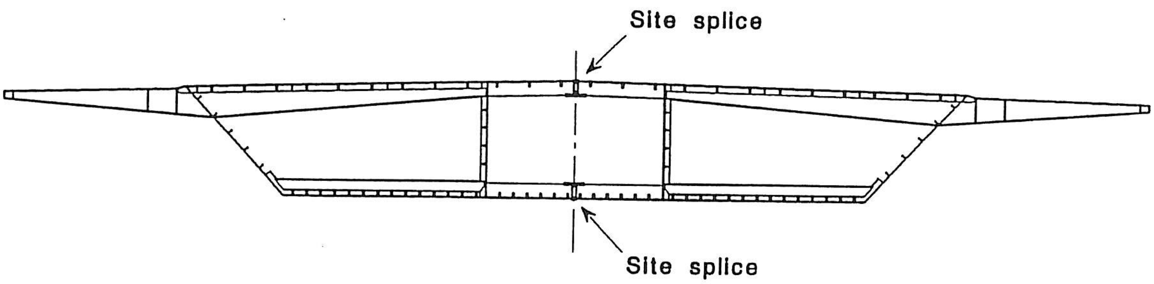


Figure 9 Typical cross-section of Melbourne bridge [2]

ESDEP

Lecture 15B.6

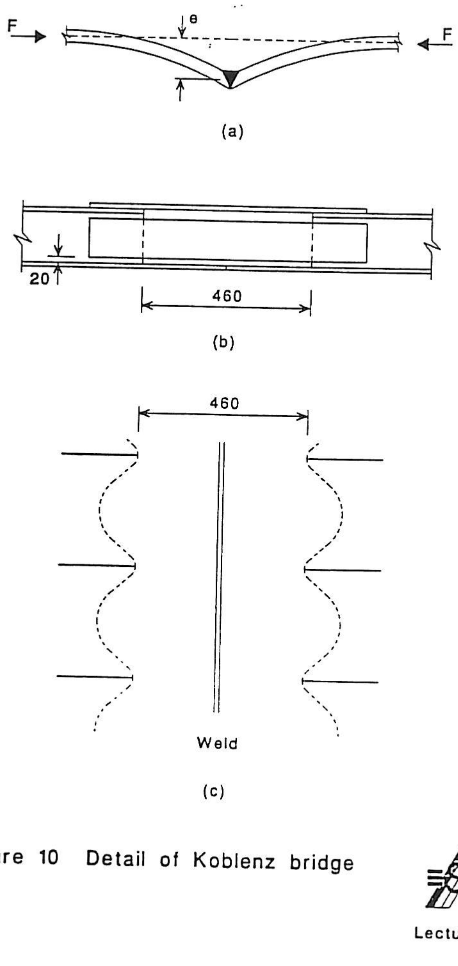


Figure 10 Detail of Koblenz bridge

ESDEP

Lecture 15B.6

LECTURE 15B.8
Cable-Stayed Bridges

FIGURES

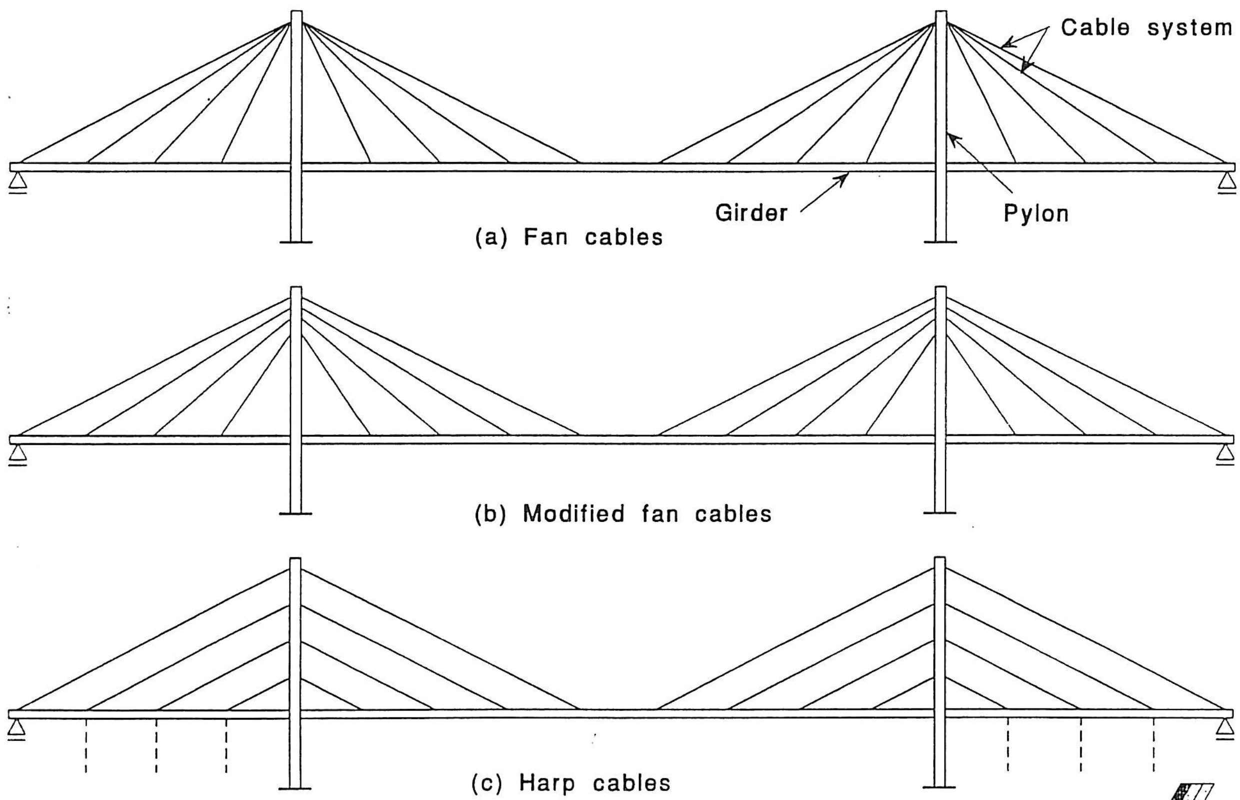


Figure 1 Types of cable stayed bridge

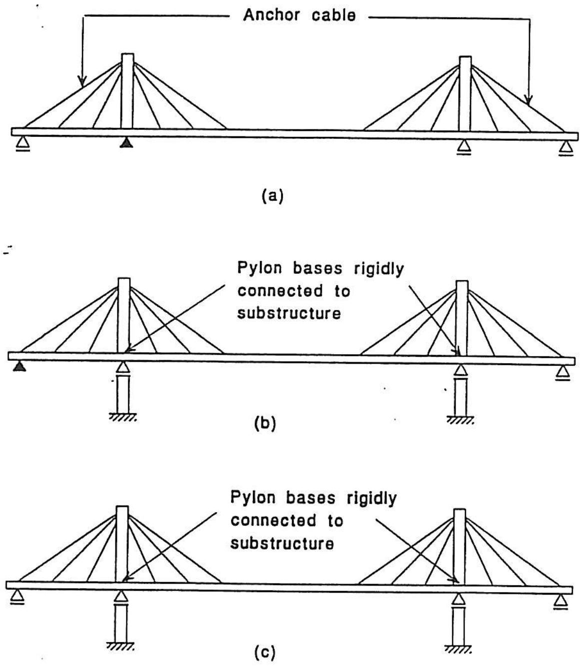


Figure 2 Support conditions for cable stayed bridges

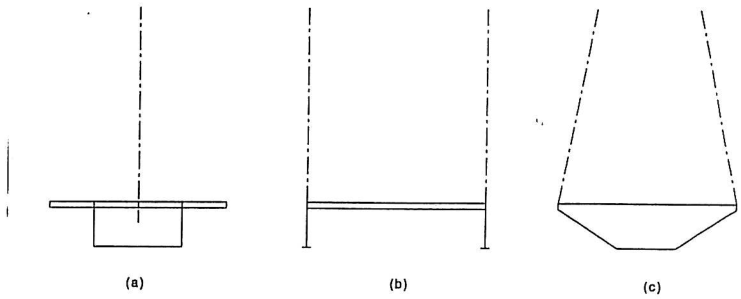


Figure 3 Alternative cable planes

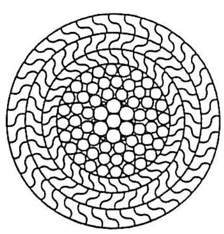


Figure 4 Lock coil cable

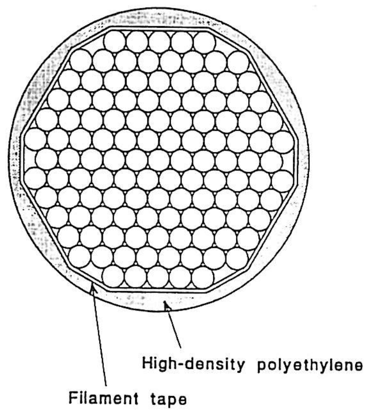


Figure 5 Parallel wire strand (PWS)

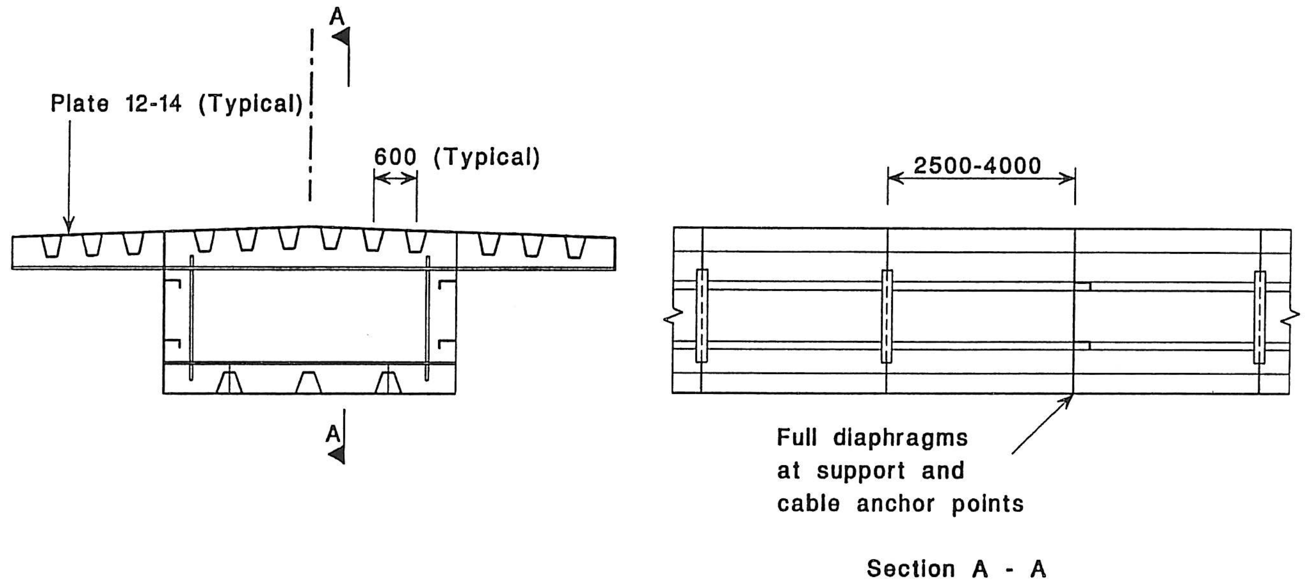


Figure 6 Typical box girder construction

Lecture 15B.8

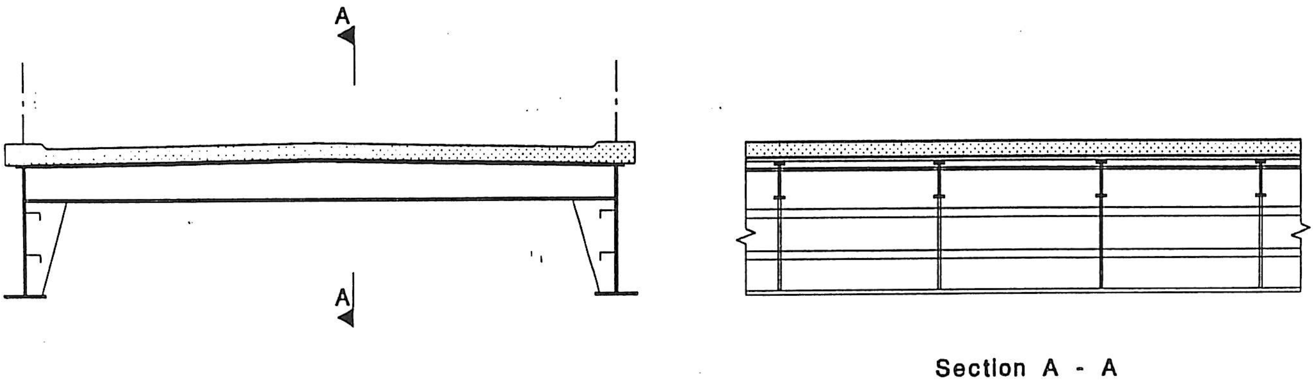
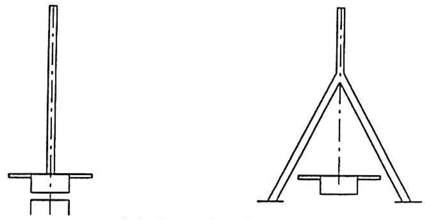
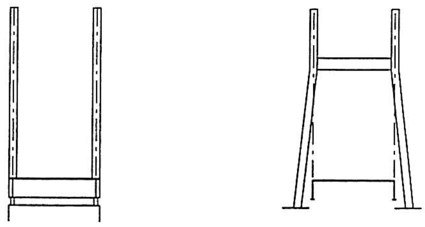


Figure 7 Typical plate girder construction

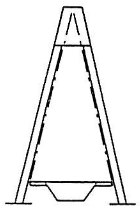
Lecture 15B.8



(a) Central cable plane



(b) Cables in parallel planes



(c) Cables in twin inclined planes

Figure 8 Pylon configurations

Lecture 15B.8

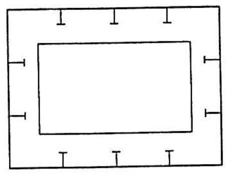
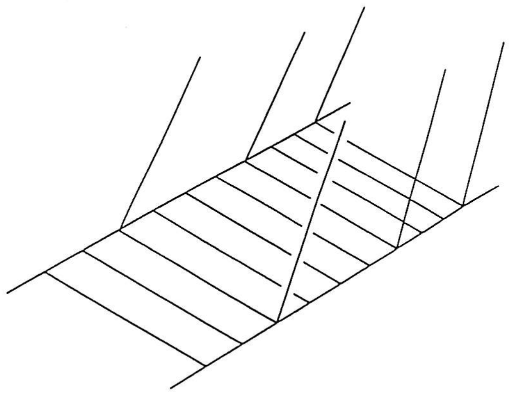
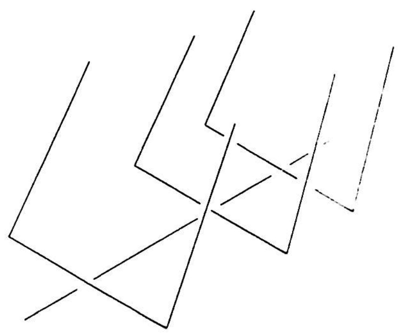


Figure 9 Typical pylon cross-section

Lecture 15B.8



(a) Twin cable planes and plate girder



(b) Inclined cable planes and a box girder

Figure 10 Analytical models for cable stayed bridges

Lecture 15B 8

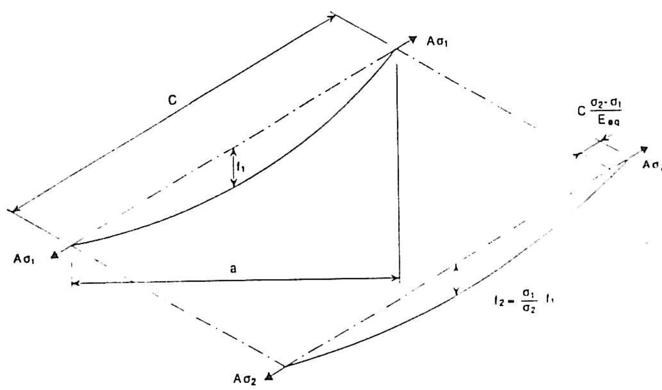


Figure 11 Influence of gravity on cable stiffness

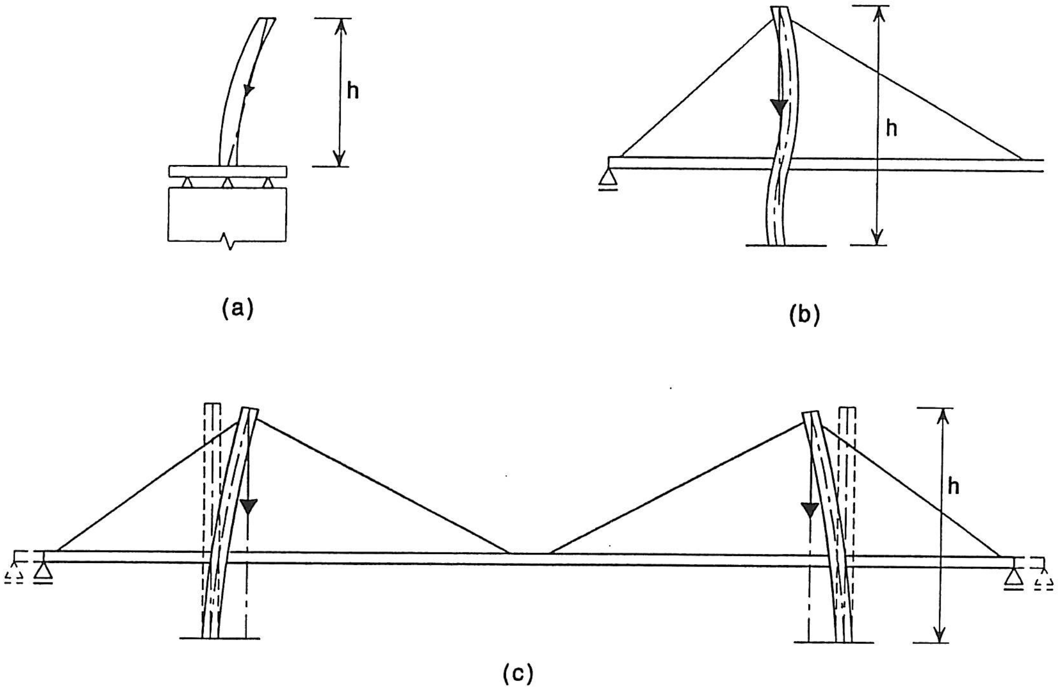


Figure 12 Stability of pylons

ESDEP

Lecture 15B.8

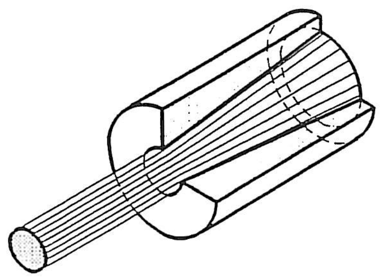


Figure 13 Typical cable anchorage

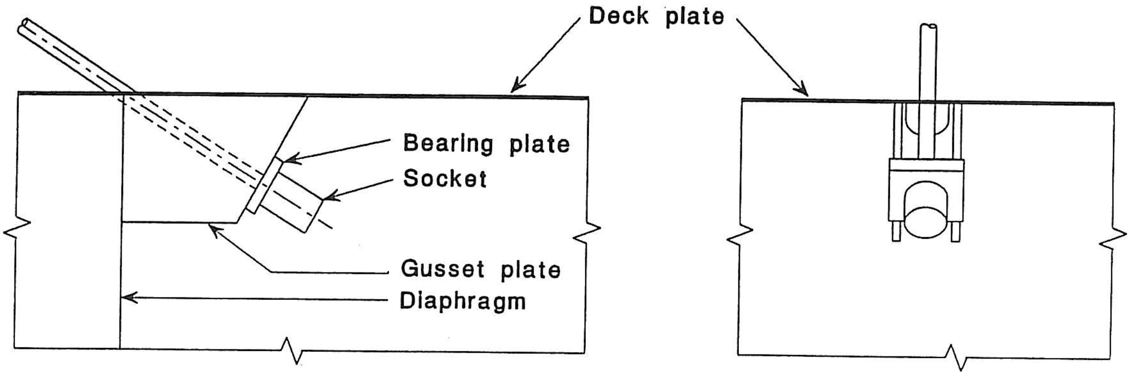


Figure 14 System for anchoring a central cable to a box girder

Lecture 15B.8

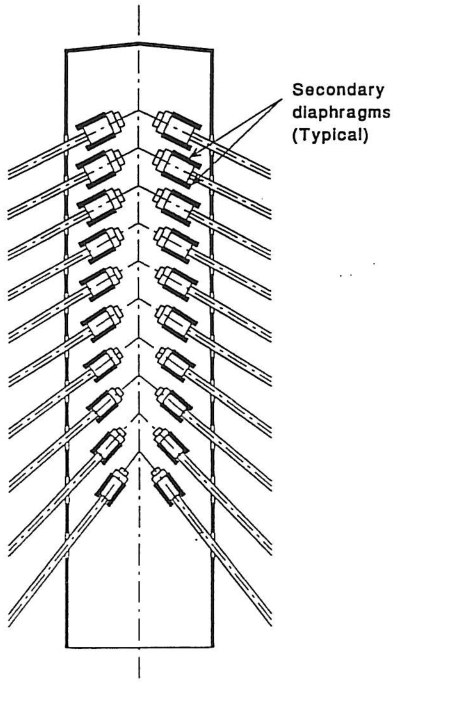


Figure 15 Anchorage system for cables at pylon in a modified fan bridge

Lecture 15B.8

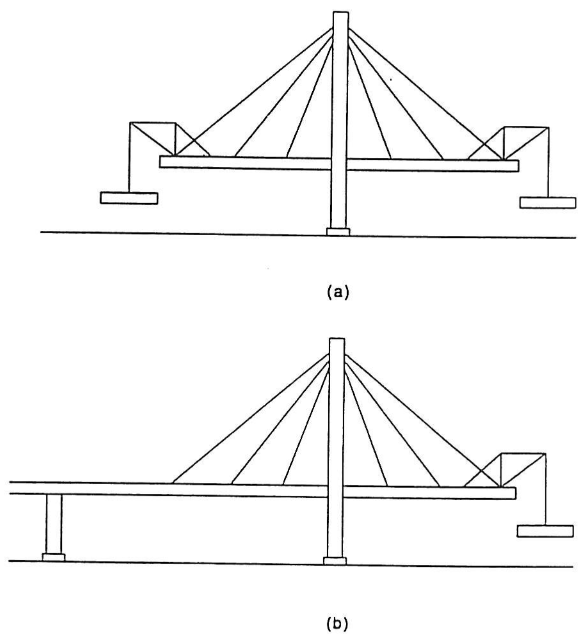


Figure 16 Methods of erection

Lecture 15B.8

LECTURE 15B.9
Suspension Bridges

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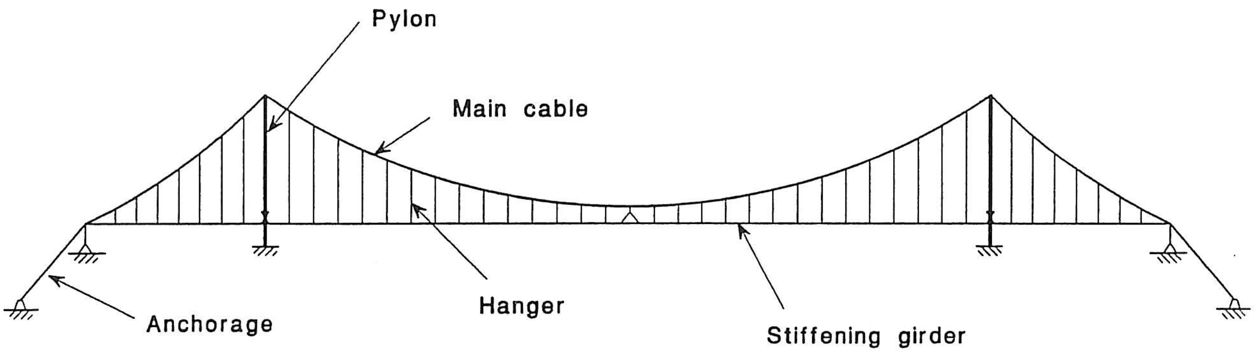


Figure 1 Principal components of a suspension bridge

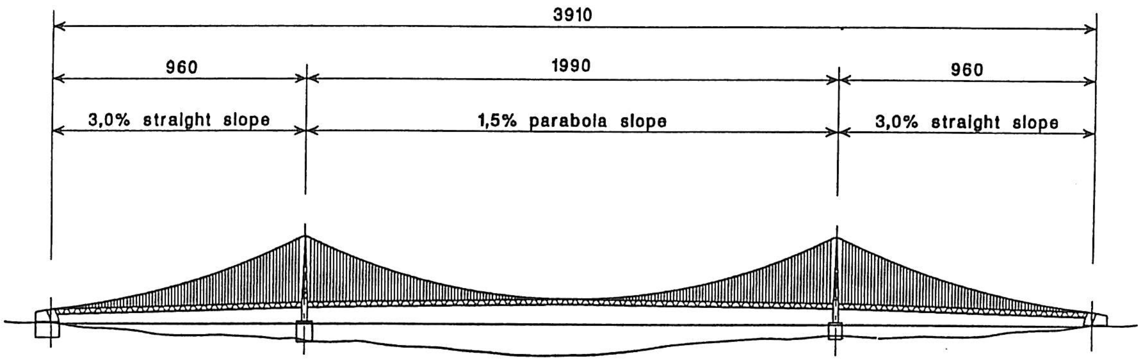


Figure 2 Akashi Kaikyo bridge

Lecture 15B.9

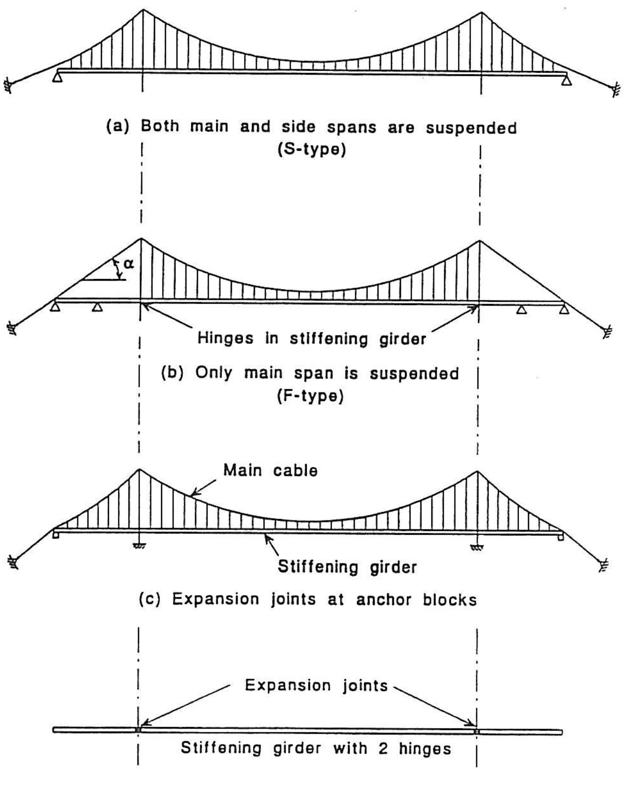


Figure 3 Classification of suspension bridges

Lecture 15B.9

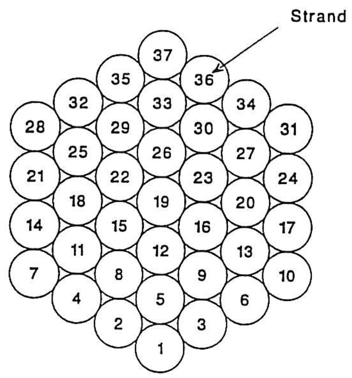


Figure 4 Pattern of strands in cable before compacting

Lecture 15B 9

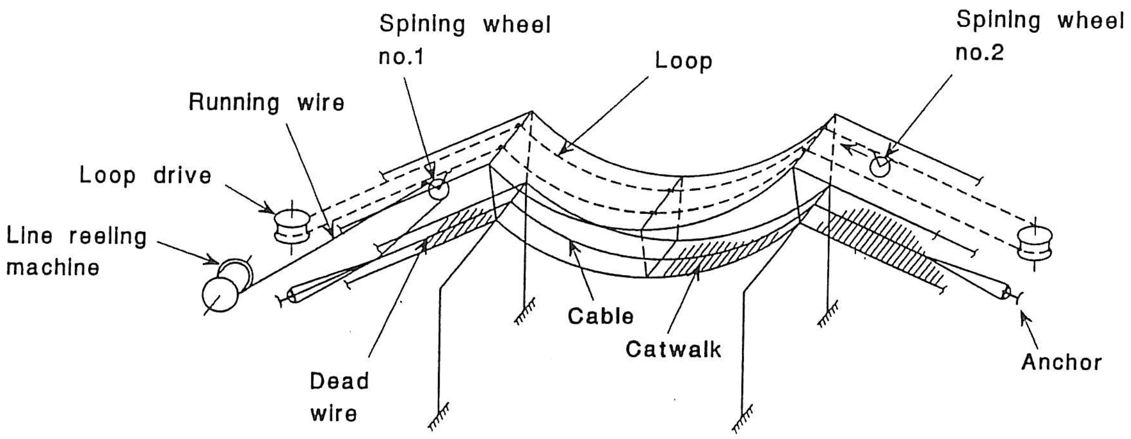


Figure 5 Cable spinning as developed by Roebling

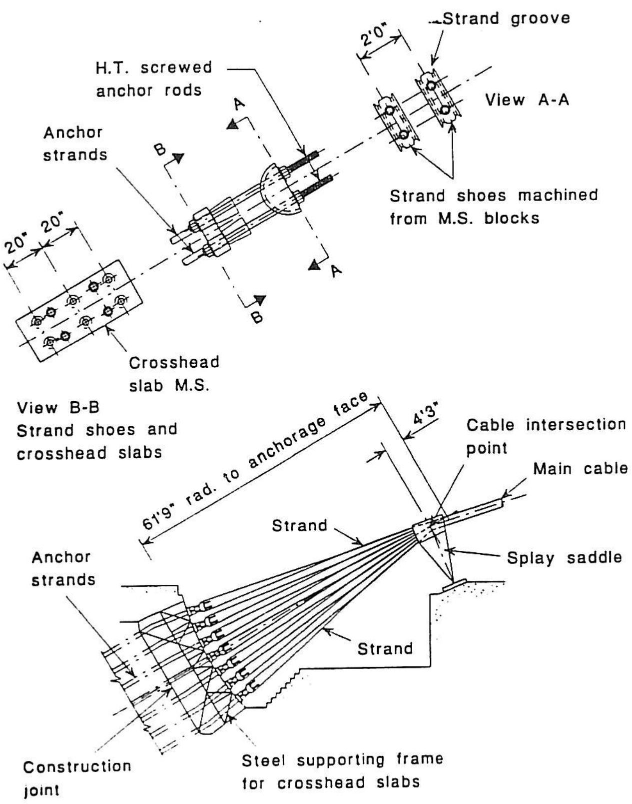


Figure 6 Details of cable anchorage for the Severn bridge

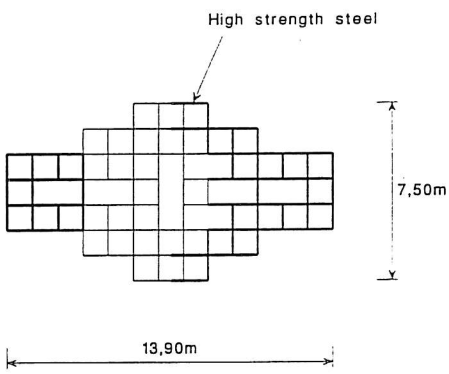


Figure 7 Cross-section of pylon: Golden gate bridge

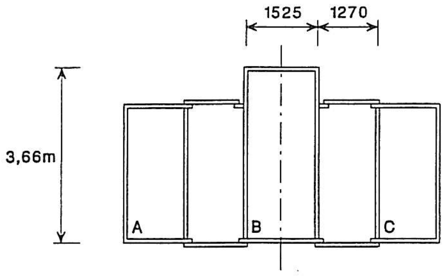


Figure 8 Cross-section of pylon: Firth of Forth bridge

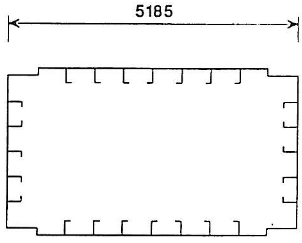


Figure 9 Cross-section of pylon: Severn bridge

Lecture 15B.9

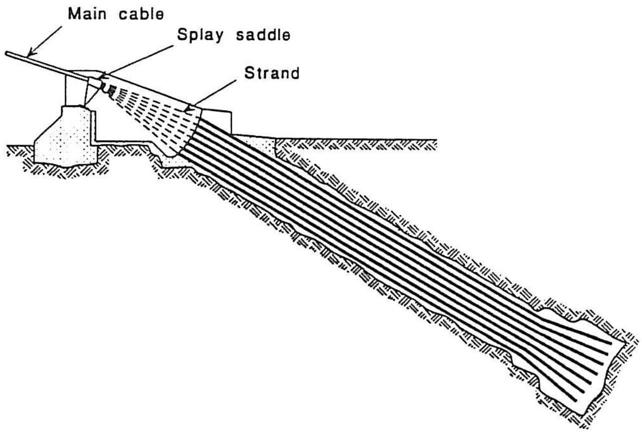


Figure 10 Firth of Forth bridge

Lecture 15B.9

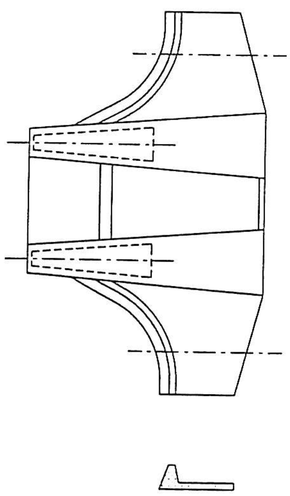


Figure 11 Concrete gravity anchorage: Lillebelt bridge

Lecture 15B.9

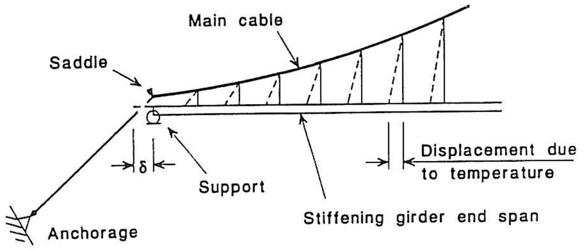


Figure 12 Influence of thermal expansion on hangers

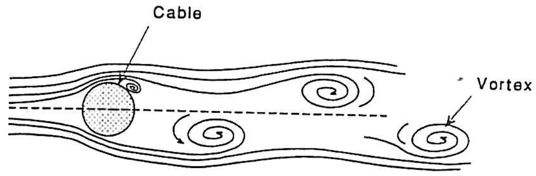


Figure 13 Vortex shedding

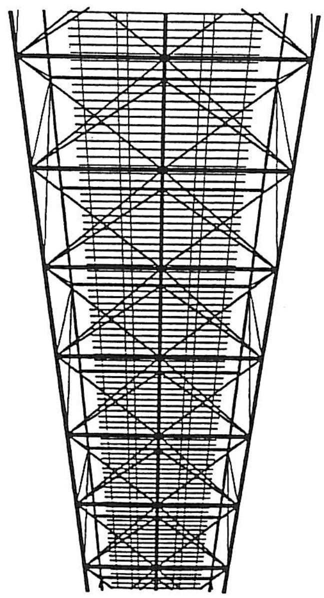


Figure 14 A view from underneath, showing the transparency of the Lisbon suspension bridge

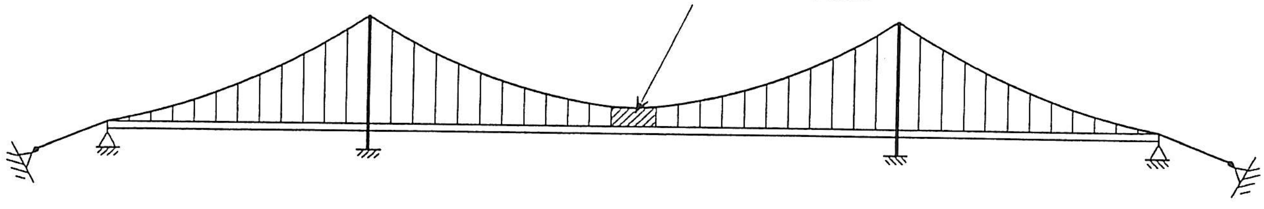


Figure 15 A technique for controlling flutter

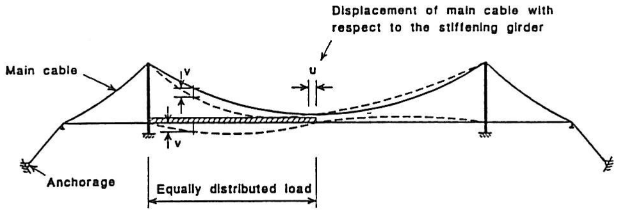
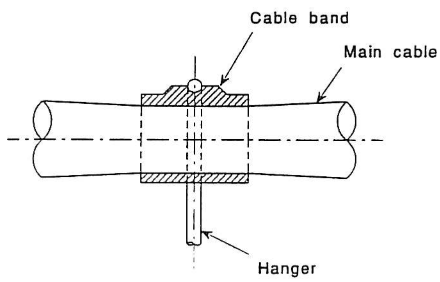


Figure 16 Deformation of the stiffening girder and displacement of the main cable due to a "half span" equally distributed load



igure 17 Cable band to main cable connection

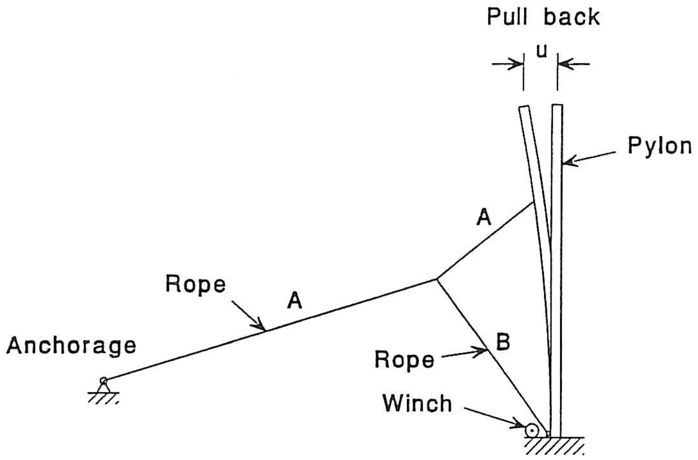


Figure 18 Presetting pylons to prestress anchor portions of main cables

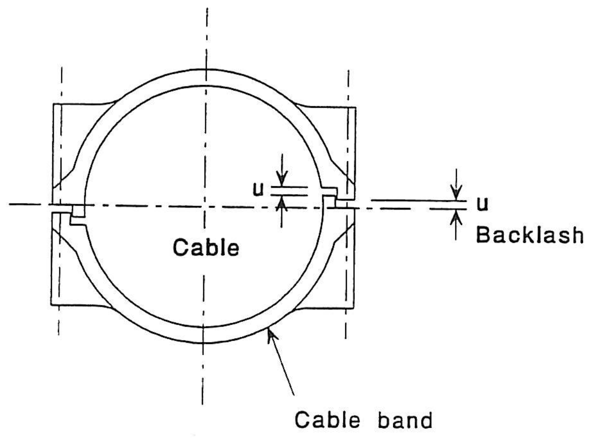


Figure 19 Backlash displacements in cable clamps

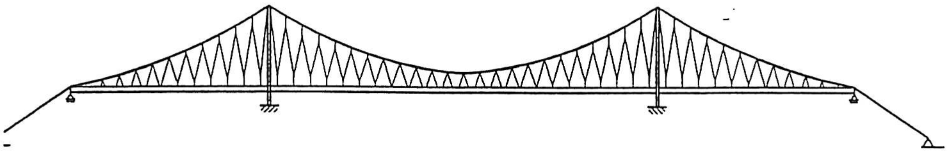


Figure 20 Hanger configuration:
Severn bridge

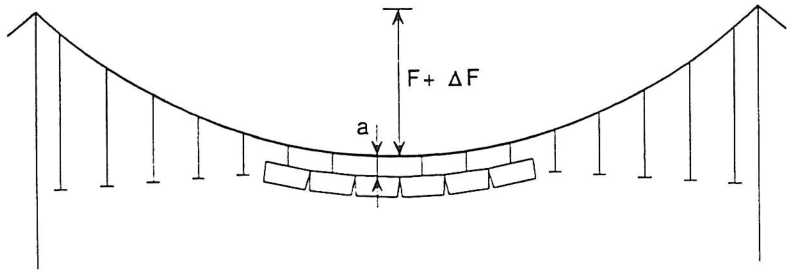


Figure 21 Cable distortion during erection
and to influence the on site
joints of stiffening girder

LECTURE 15B.10
Bridge Equipment

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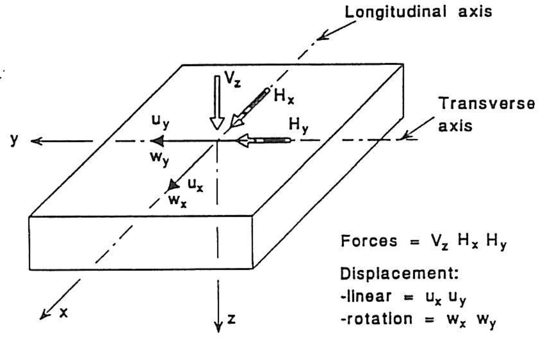


Figure 1 Forces and displacements on bearings

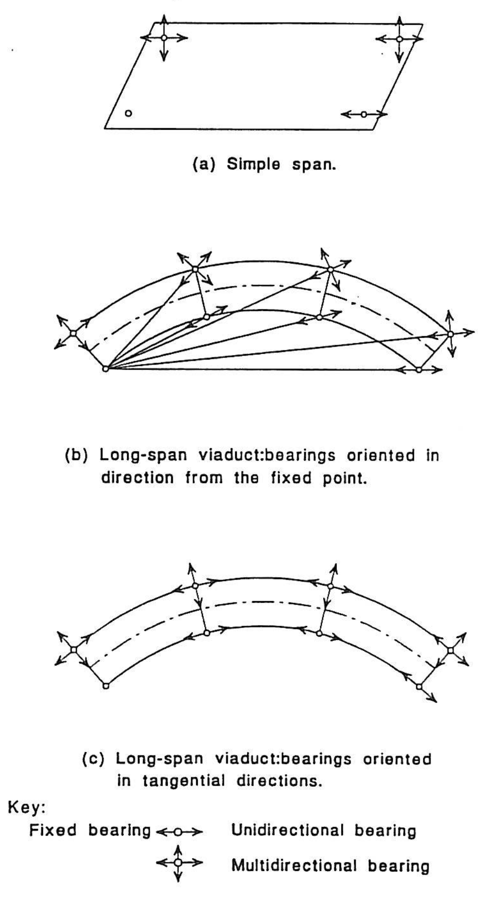


Figure 2 Layout of bearing systems.

Lecture 15B.10

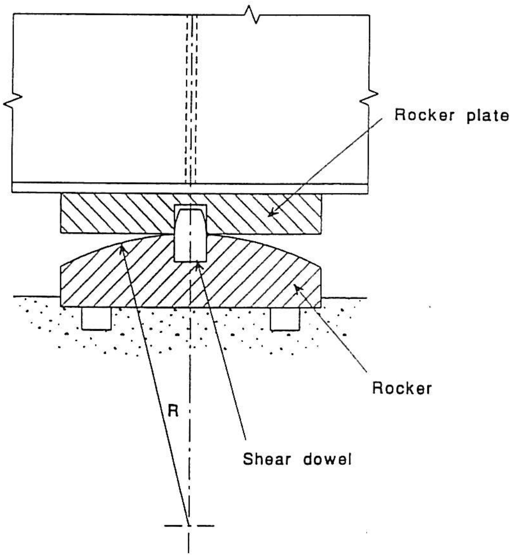


Figure 3 Elevation of line rocker bearing.

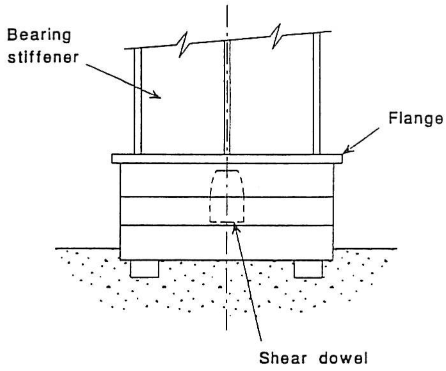


Figure 4 Section through line rocker bearing.

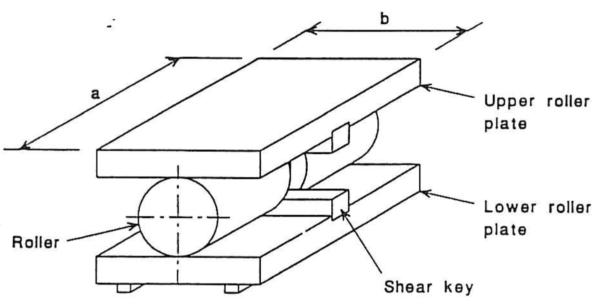


Figure 5 Roller bearing.

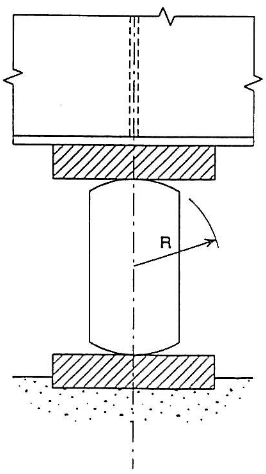


Figure 6 Flat-sided roller bearing.

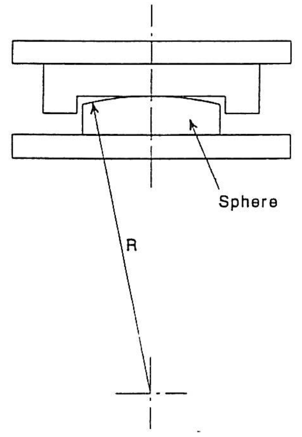


Figure 7 Plane/spherical point bearing.

Lecture 15B.10

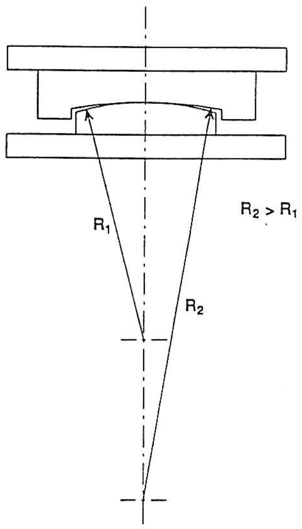


Figure 8 Double spherical point bearing.

Lecture 15B.10

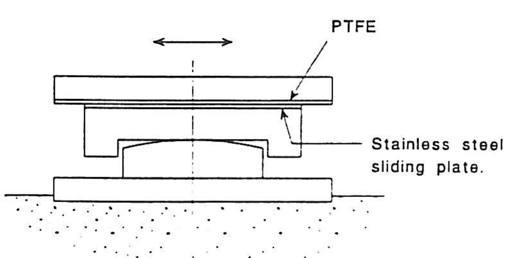


Figure 9 Sliding point bearing.

Lecture 15B.10

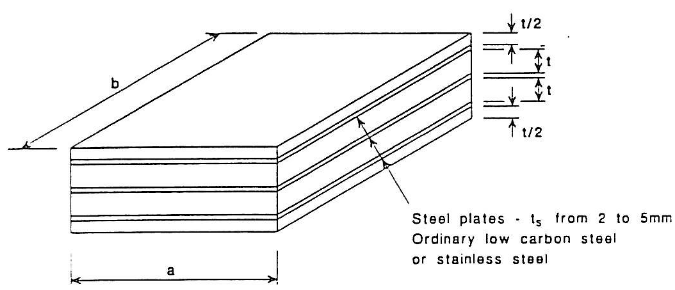


Figure 10 Reinforced elastomeric bearing system

Lecture 15B.10

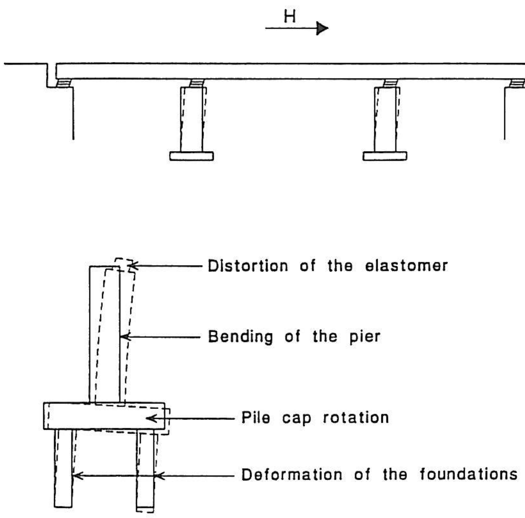


Figure 11 Location and action of the bearings.

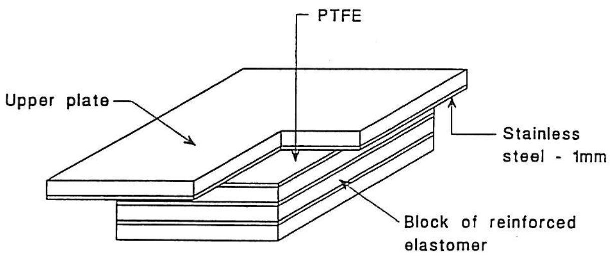


Figure 12 Sliding bearings in reinforced elastomer.

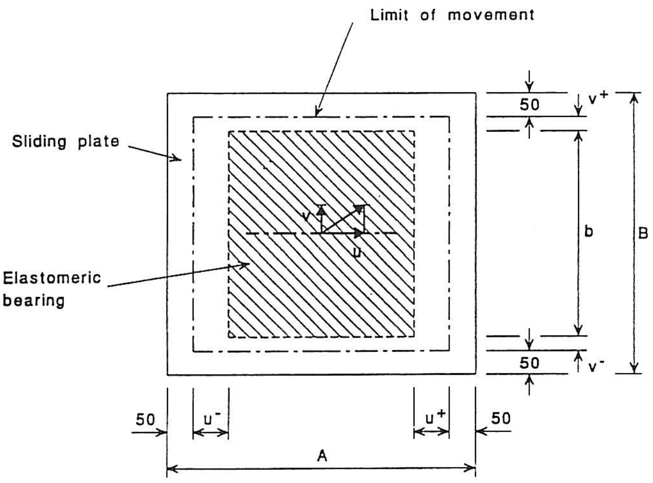


Figure 13 Layout of elastomeric sliding bearing

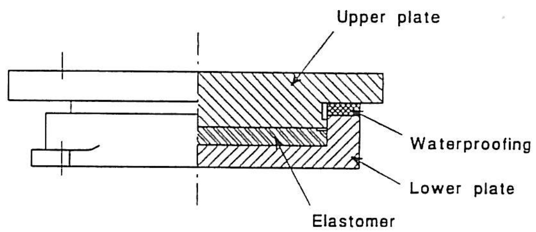


Figure 14 Fixed pot bearing.

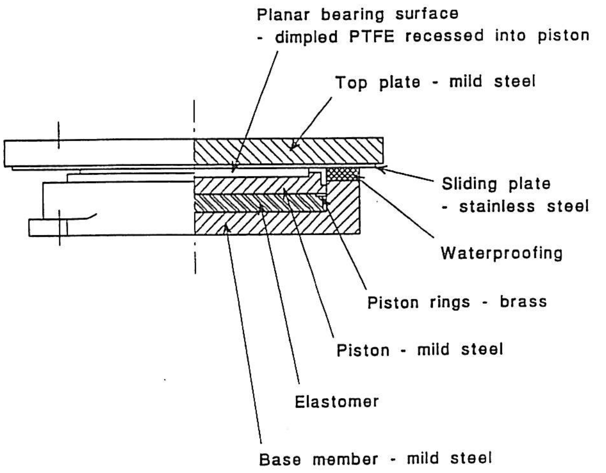


Figure 15 Multidirectional pot bearing.

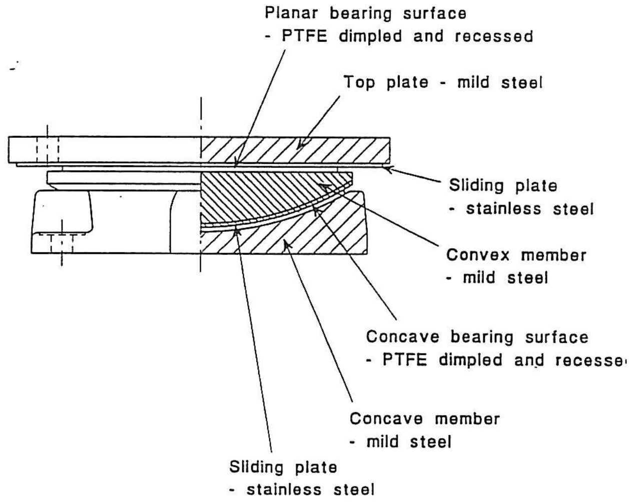


Figure 16 Bearings with spherical gap.

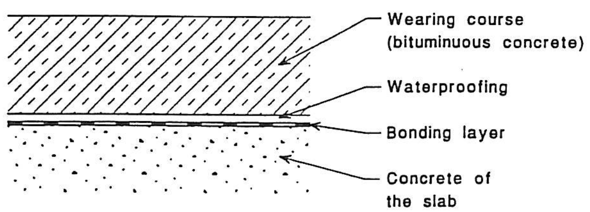


Figure 17 Finishing on concrete slab.

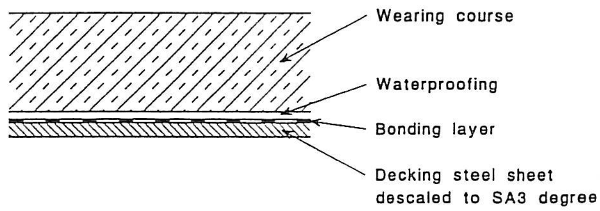
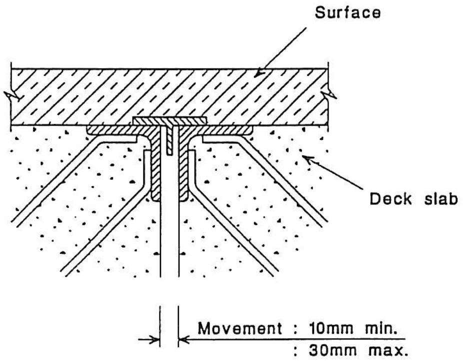


Figure 18 Finishing on orthotropic slab.



(a) Buried joint

Figure 19a Types of covered expansion joint.

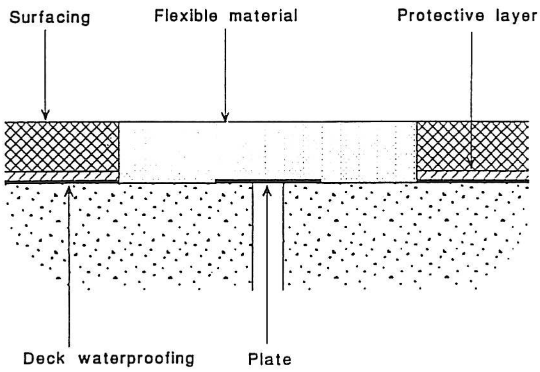


Figure 19b Asphaltic plug joint

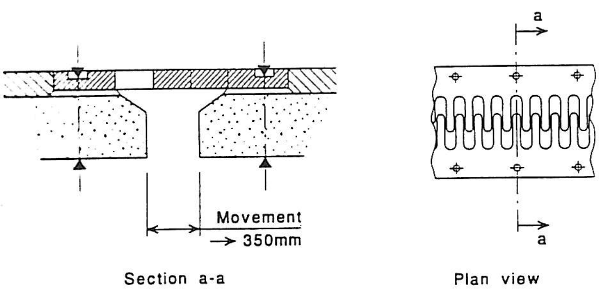


Figure 20 Toothed joint.

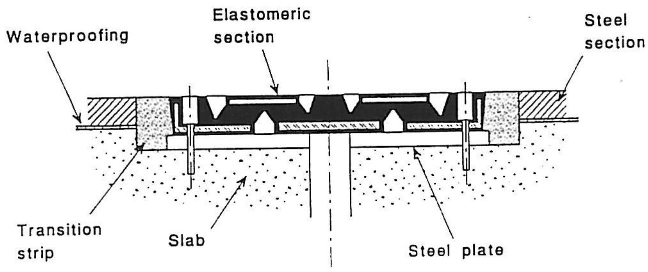


Figure 21 Joint with elastomeric extensions.

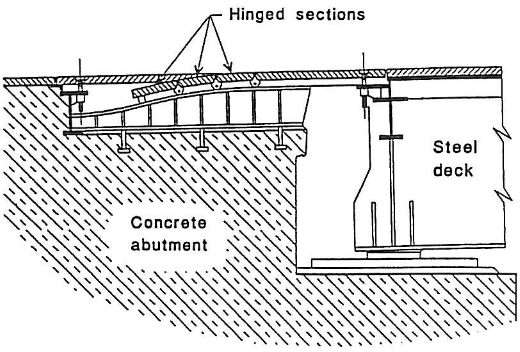


Figure 22 Roller shutter joint.

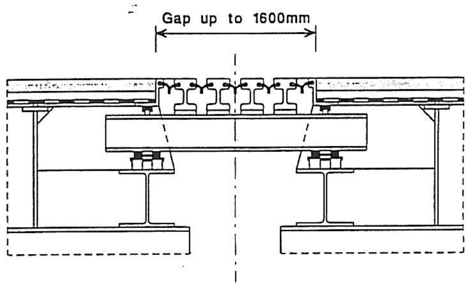


Figure 23 Bellows joints.

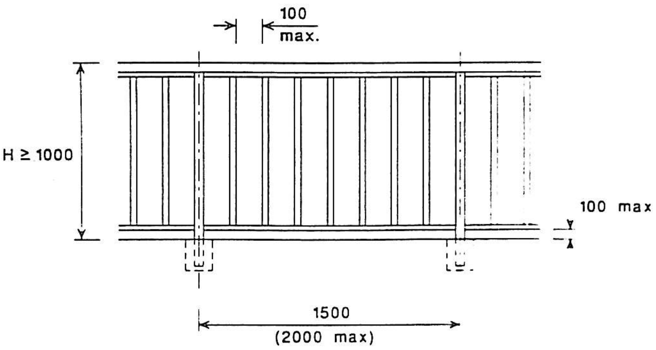


Figure 24 Pedestrian parapet.

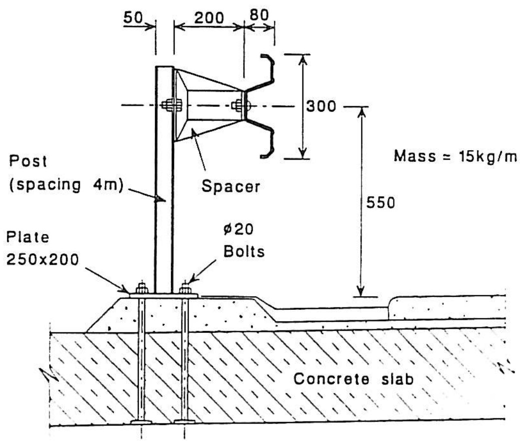
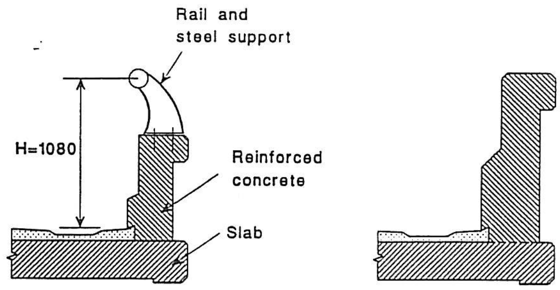


Figure 25 Crash barrier



(a) Californian breast high wall

(b) Barrier in reinforced concrete

Figure 26 Examples of rigid safety fences

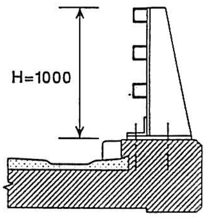
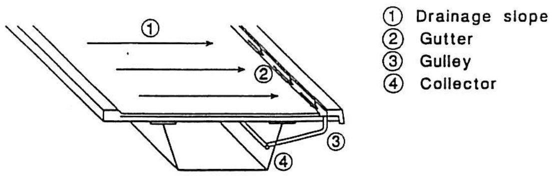
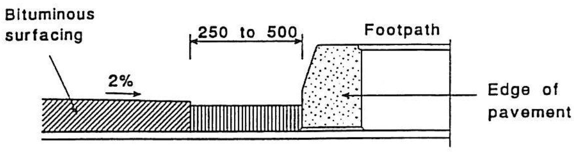


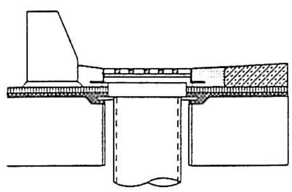
Figure 27 Typical flexible safety fance



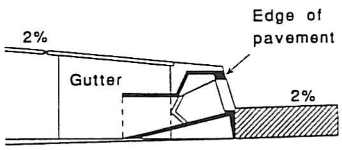
(a) General arrangement



(b) Gutter details

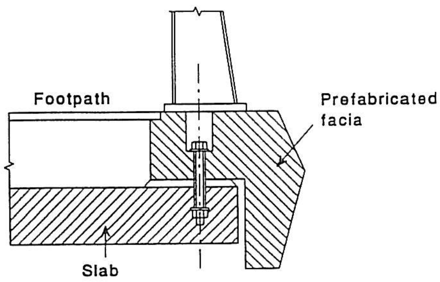


(c) Gulley

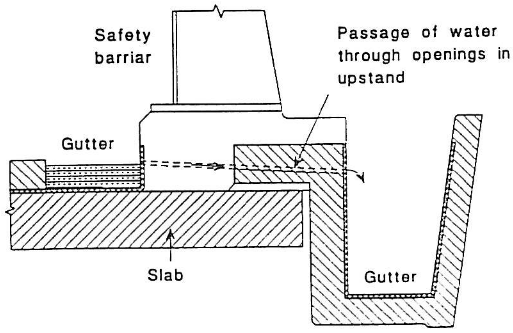


(d) Drainage under pavement

Figure 28 Drainage of rainwater



(a) External facia



(b) Facia with integrated gutter

Figure 29 Fascias

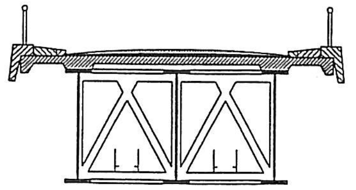


Figure 30 Fixed inspection walkways

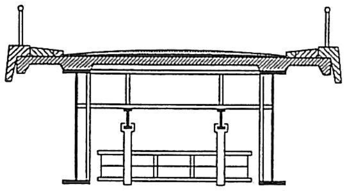
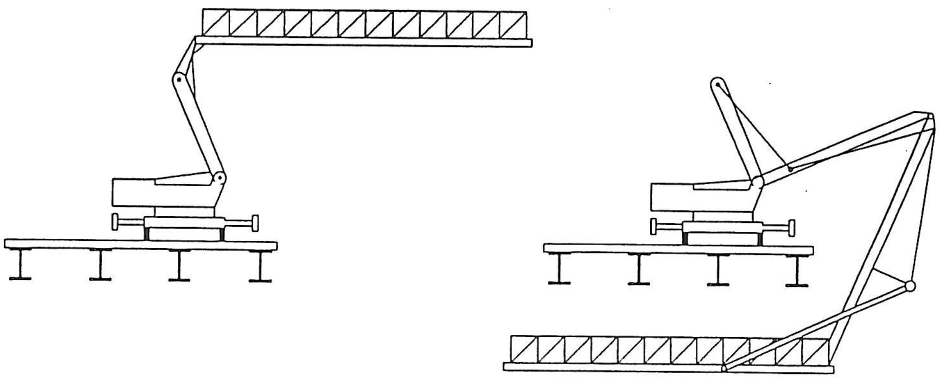


Figure 31 Moveable inspection gantry



(a) (b)

Figure 32 Special mobile inspection equipment

LECTURE 8.5.1
Design of Box Girders

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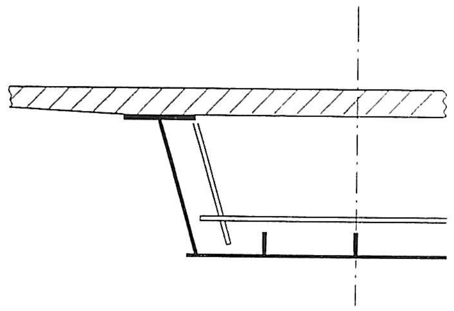

Figure 2 (a) Cross-section of a box beam with composite concrete top flange

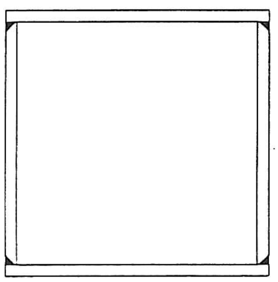

Figure 1 Cross-section of a box girder used in buildings

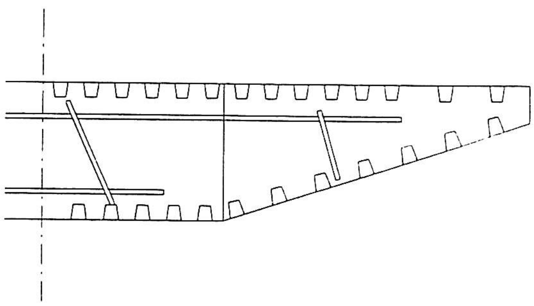

Figure 2 (b) Cross-section of an orthotropic box beam

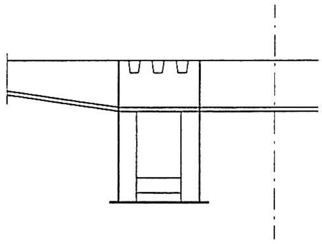

Figure 3 Composite slab with twin box beams

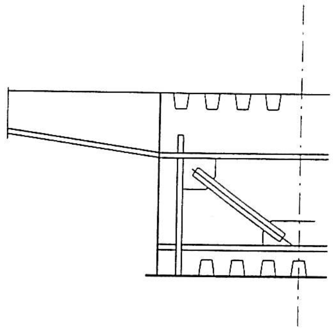

Figure 4 Reinforcement of the cross-section of an orthotropic box beam

Lecture 8.5.1

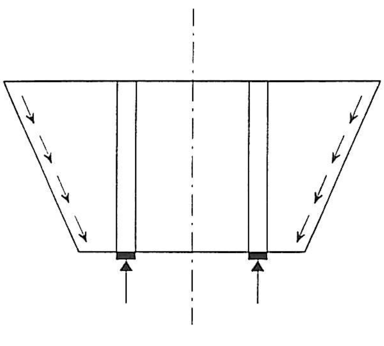

Figure 5 Transfer of reactions through support diaphragms

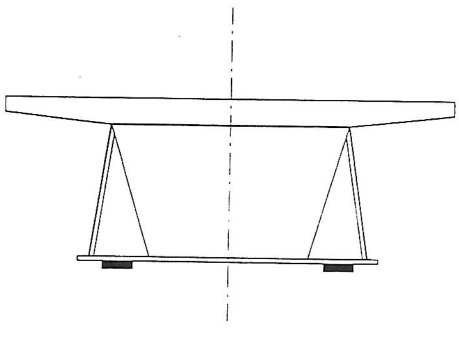

Figure 6 Load-bearing stiffeners external to a box girder

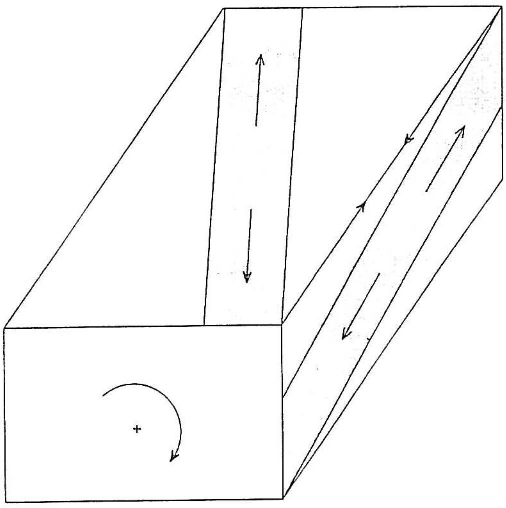

Figure 7 Tension fields developed under torsion

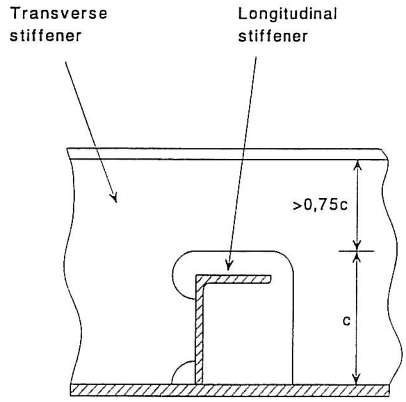

Figure 8 Longitudinal stiffener passing through transverse stiffener

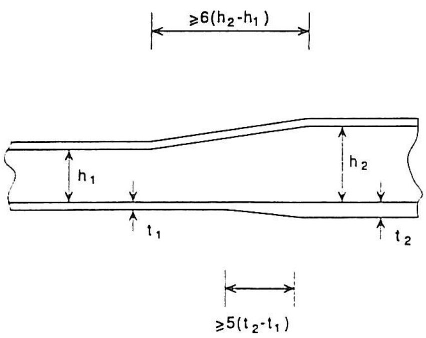

Figure 9 Tapering of longitudinal stiffener

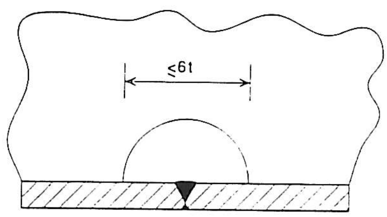

Figure 10 Cut-out to allow butt welding

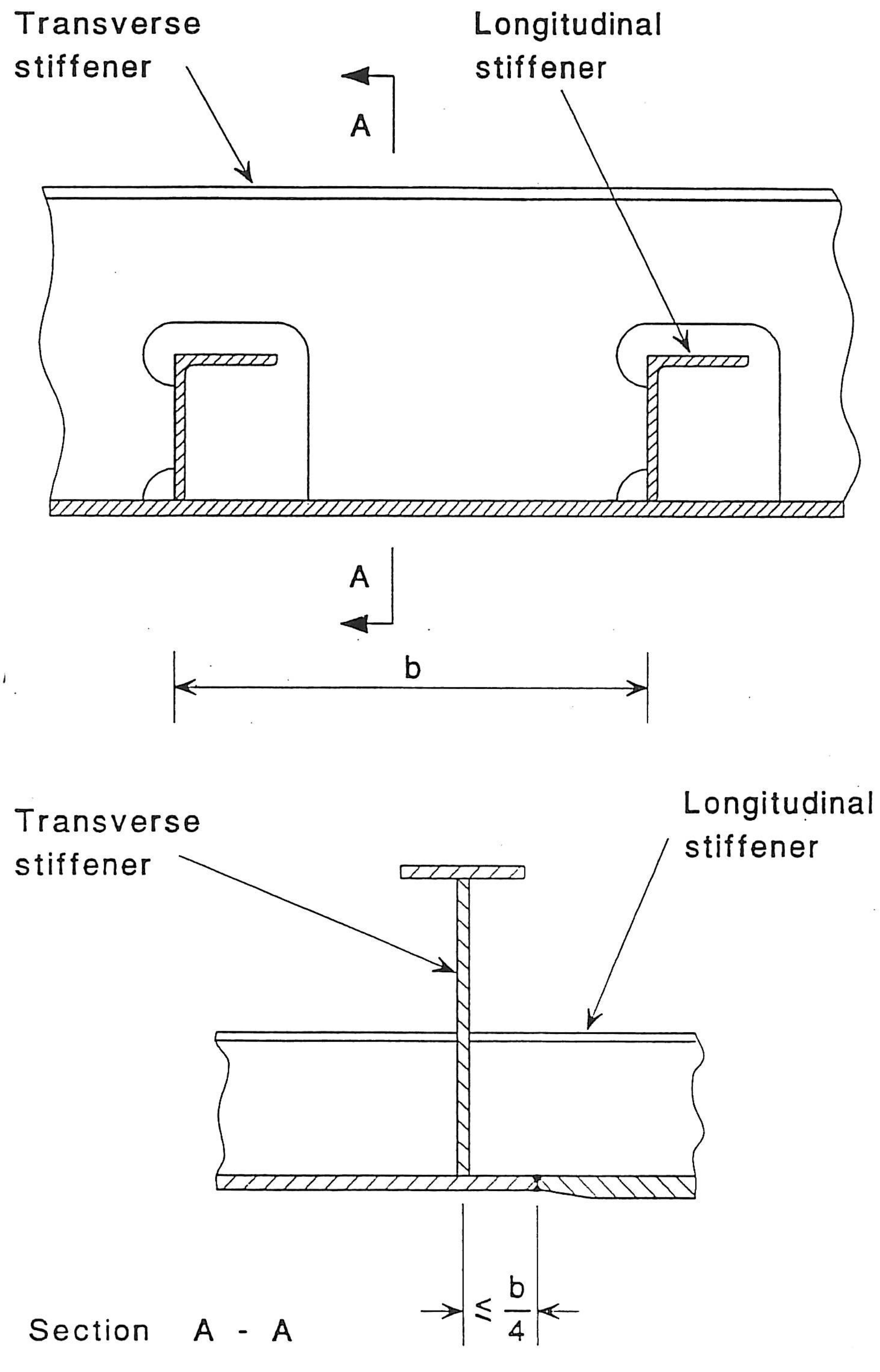

Figure 11 Transverse stiffener welded to thinner plate adjacent to transverse butt weld in the plate

LECTURE 8.5.2
Advanced Methods for Box Girder Bridges

FIGURES

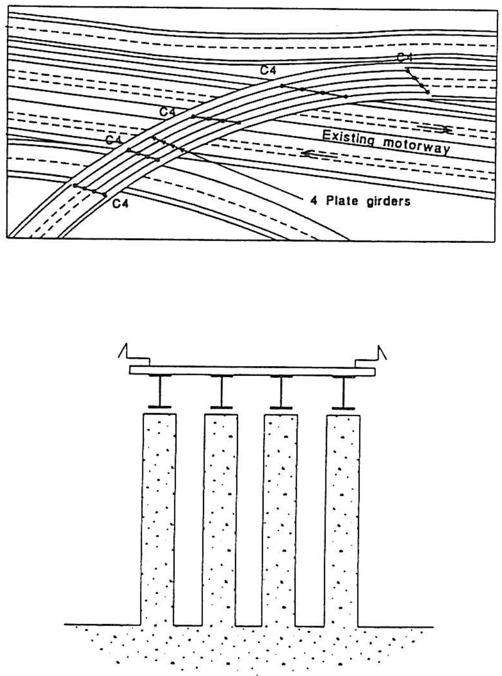

Figure 1 Plate girder bridge

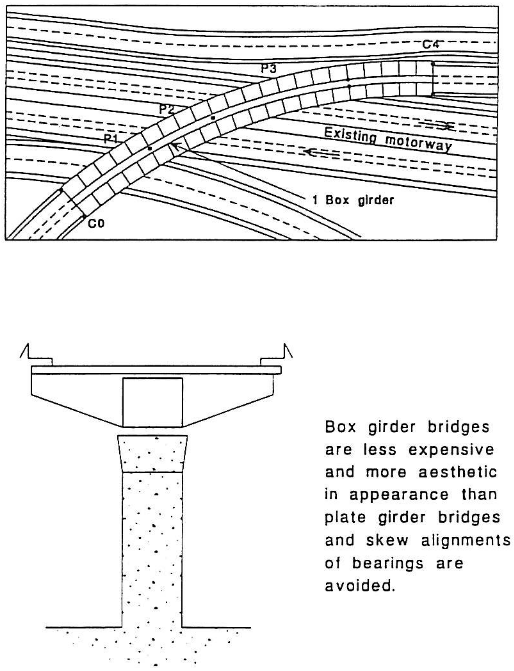

Figure 2 Box girder bridge

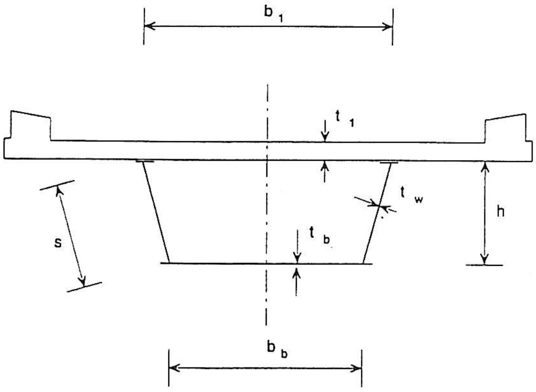

Figure 3 Composite box girder bridge with composite upper deck

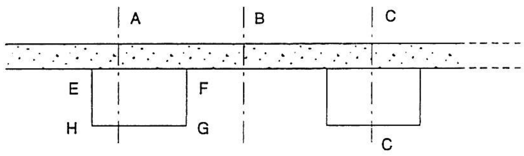

Figure 4 Interpretation of the output of a grillage analysis

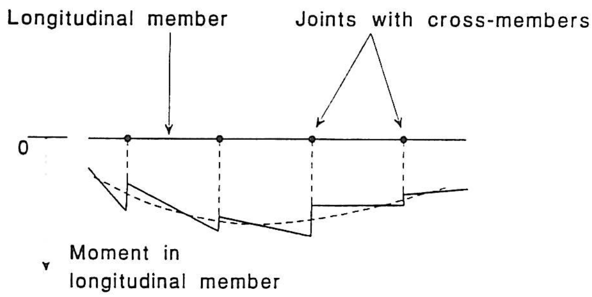

Figure 5 Typical bending or torsional moments given by a grillage analysis

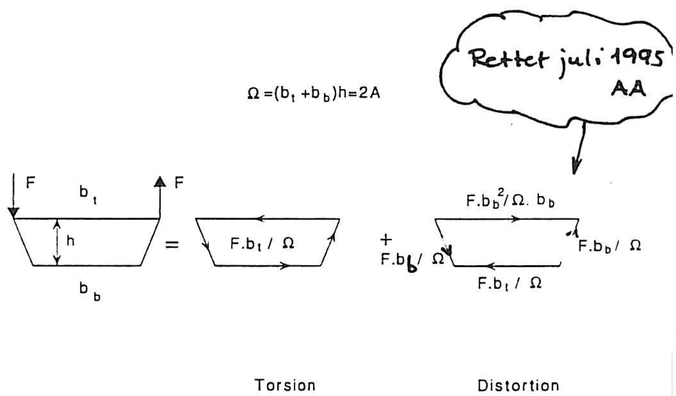

Figure 6 Computation of distortion force

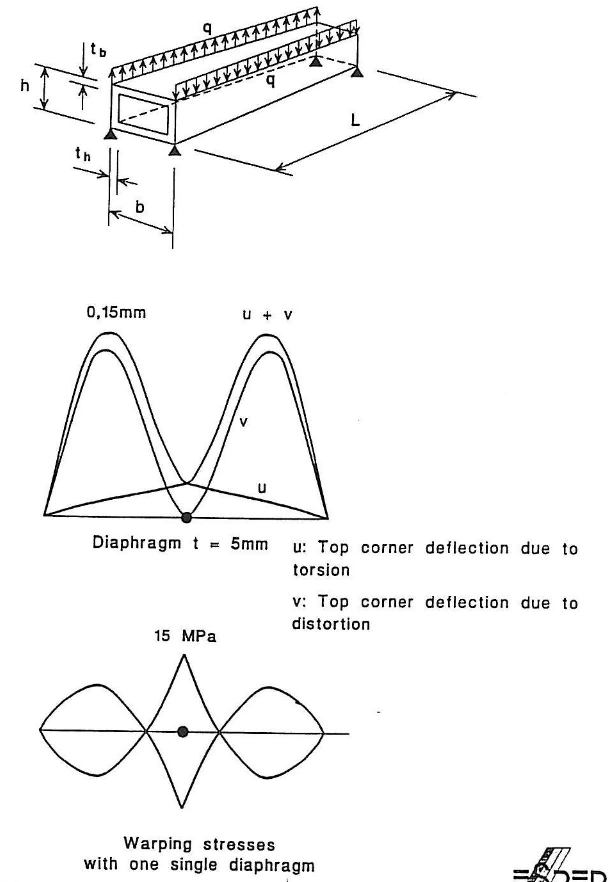

Figure 7A Influence of diaphragm separation - one diaphragm

Lecture 8.5.2

Limit conditions on bearings:
flexure rotation-free
torsional rotation-blocked
undeformable diaphragms at ends
no warping stress at the ends

Numerically:
$L = 2m$
$b = 0,10m$ $t_b = 0,001m$
$h = 0,05m$ $t_h = 0,003m$
$E = 200.000$ N/mm $\nu = 0,3$
$q = 250$ N/ml

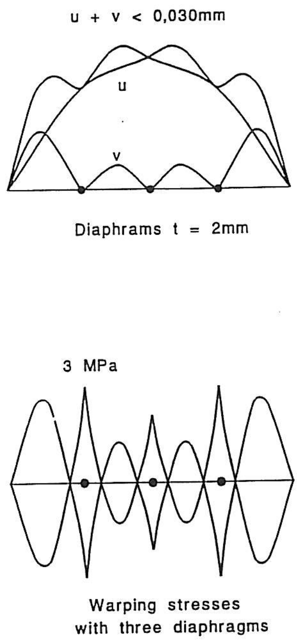

Figure 7B Influence of diaphragm separation - three diaphragms

Lecture 8.5.2

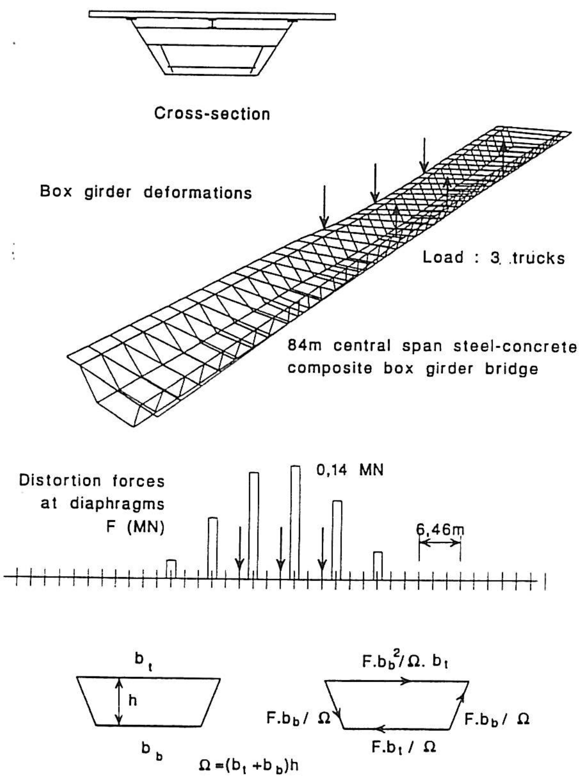

Figure 8 Distribution of the distortion forces between the cross-frames of a bridge

Lecture 8.5.2

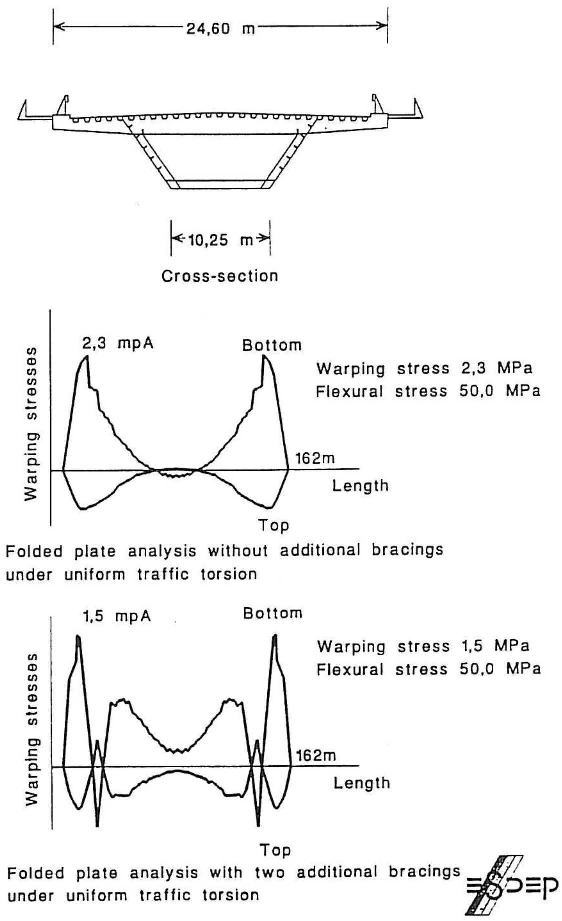

Figure 9 The Cheviré bridge

Lecture 8.5.2