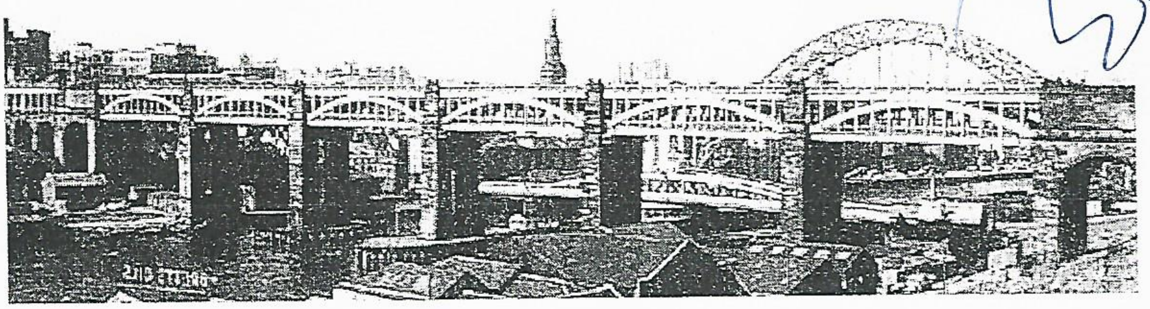
Mechanics/structure
عمارة

FINAL STRUCTURE

1) Explain why the elevated arches, such as the one shown below, are almost always of the same type "tide arch"!



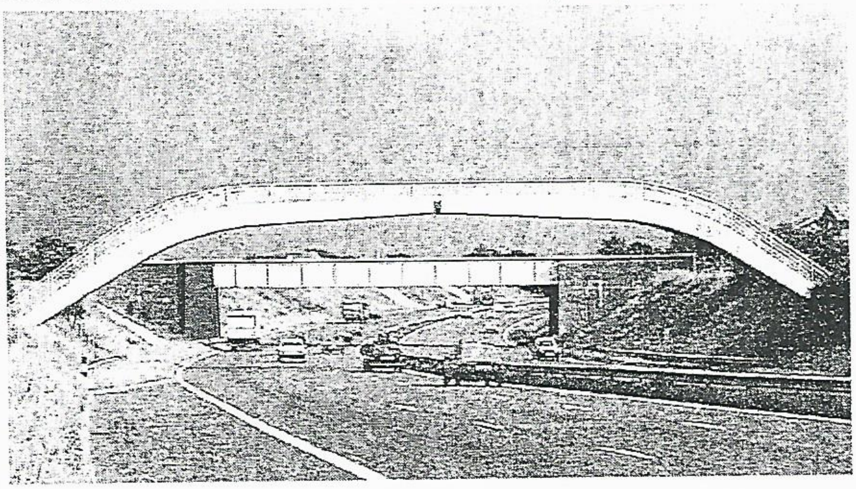
2) Explain the concept (how it is done) and the purpose of pre-stressing concrete beams!

3) Explain why shell structures are thin in cross-section!

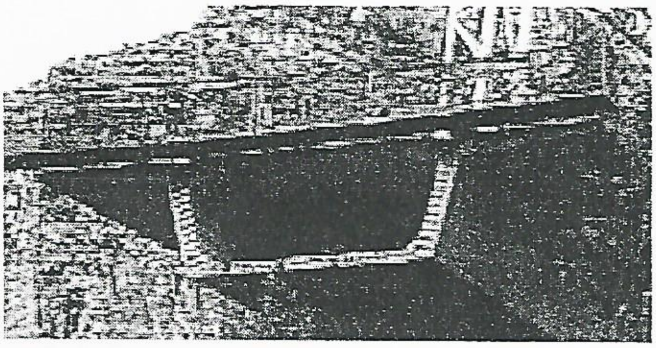
4) Discuss the effect of span/sag (L/f) ratio on the design of suspended structure.

5) What are the basic types of arches? Explain their main characteristic!

6) The bridge is three hinged arch with hinges at both end support and at mid-span. Explain the variation in the cross-section of the two bridge segments!



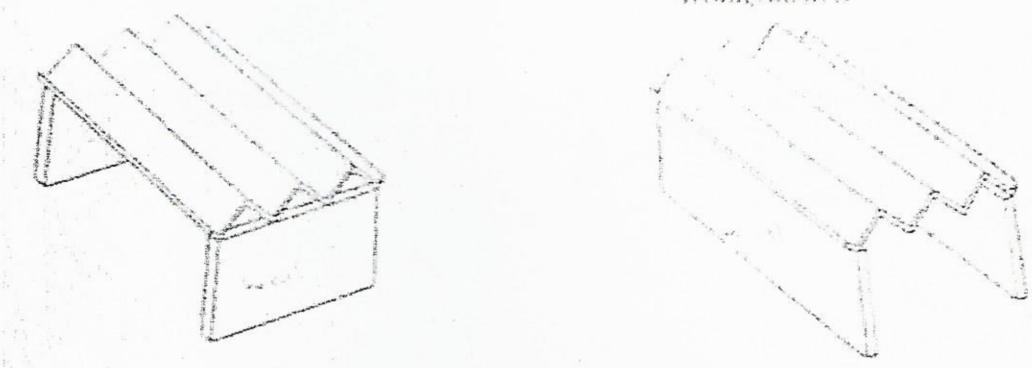
plain the concept of the reinforced concrete T-beam, or hollow beams!



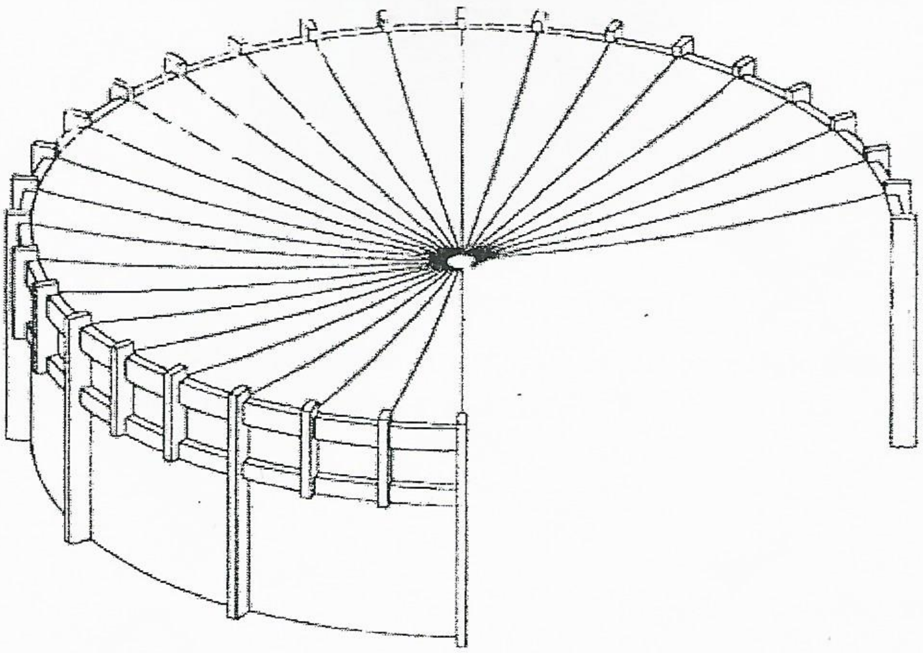
ich arrangement/orientation of the folded plate shown below is correct and which is wrong? plain!

Arrangement A

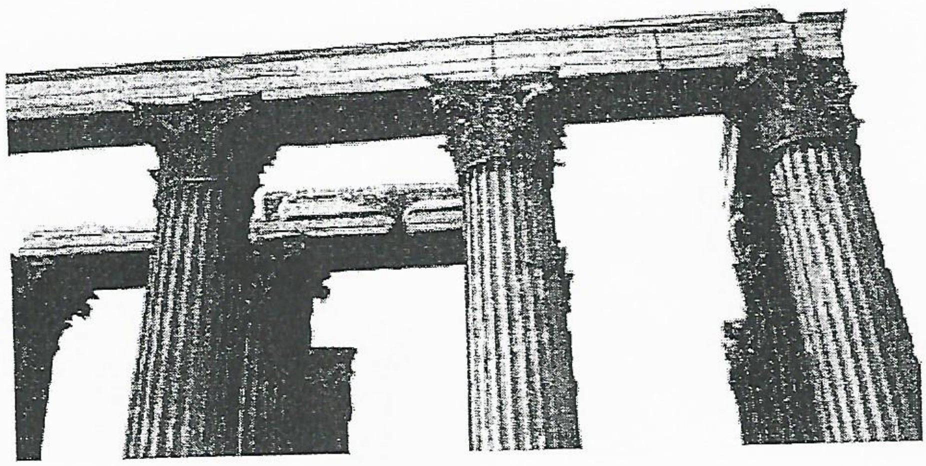
Arrangement B



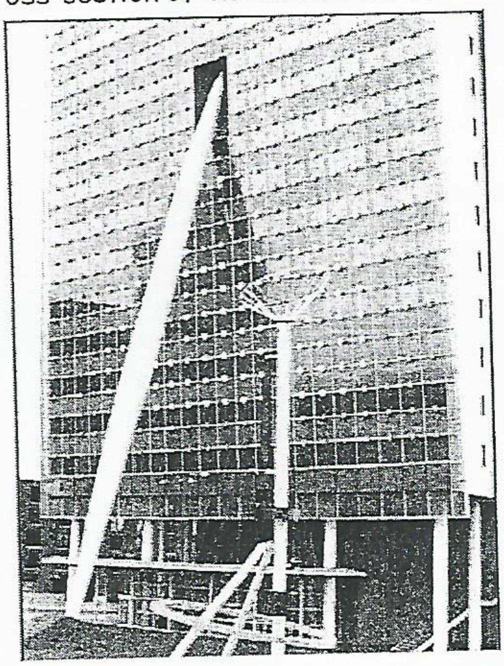
plain the behavior of the suspended roof system shown in the figure!



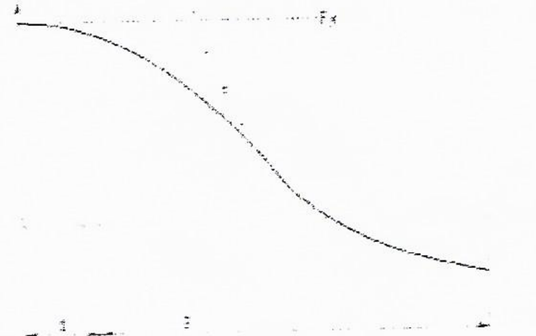
xplain why the columns are spaced so closely in the figure shown!



Explain the variation of the cross-section of the column indicated by the arrow!

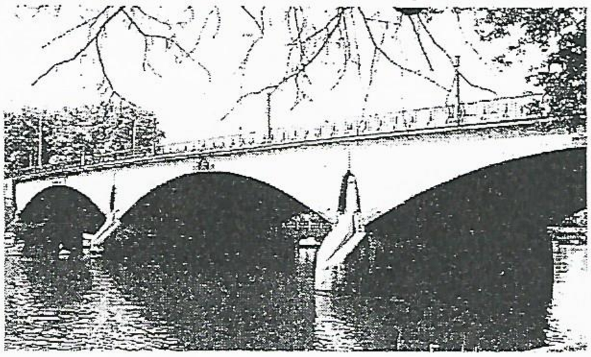


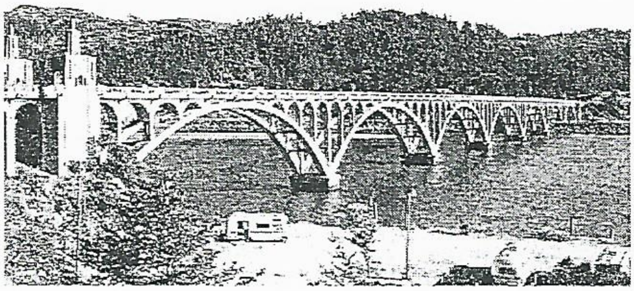
)Shown is the column strength curve. How do you describe the **geometric properties** and the **failure mode** of columns located in **region 1** and **region 2**?



What measures can be implemented to increase the carrying capacity (P_{cr}) of a certain column?

14) In the figures below, explain why intermediate piers (supports) are of such small size while those at both ends of the bridge are massive!





15) The steel simply supported I-section has been modified by welding plates to its flanges as shown in the figure below. Explain the purpose of such a modification.

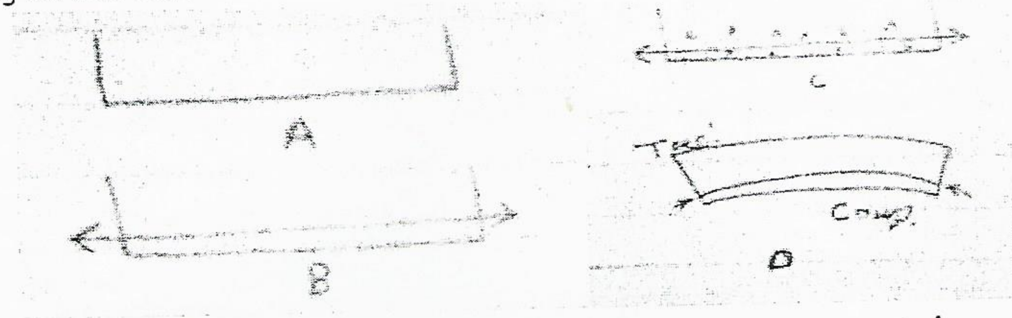
ADDITIONS

1) Define the thermal strain and its effects.
2) Axial deformation plays a significant role in cable-suspended structures. Explain!
3) Folding plates are very efficient roof structure. Explain!
4) Explain why keep increasing the beam cross-section is not efficient!
5) Explain the concept of reinforced concrete beams.
6) Seismic Load.
7) Explain the concept (how it is done) and the purpose of **post tension** concrete beams!

FINAL STRUCTURE

1) Because in tide arch the girder itself ties both ends of the arch together, thus the girder takes care of the horizontal thrust, no horizontal supports needed, so we rely only on the vertical supports to hold the arch.

2) Pre-stressed concrete beams are supposed to resist large loads or to provide large spans and control cracks by introduce initially negative deflection before applying service load, so after loading final deflection remains within acceptable magnitude.
   How it's done:
   a) Install the frame work needed.
   b) Install and pre-tension reinforcement (strands).
   c) Pour fresh concrete.
   d) After concrete attains certain strength, cut off the strands.
   e) Applying service load.



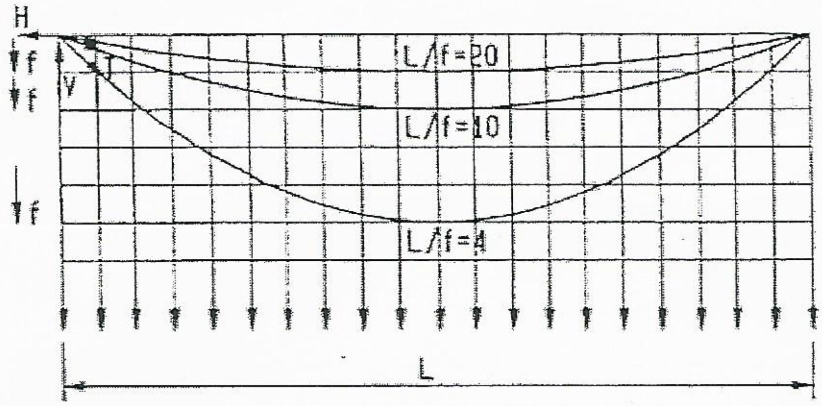
3) Shell structures are continuous curvature, internal forces are mainly compressive in the direction of curvature, no or small bending moment or shear force introduced, uniformly distributed stress in the cross-section, thus efficient use of the material, which lead to small or thin cross-section.

4) The span/sag ratio of suspended roofs is an important design factor.

   a) Small sag cause large cable force and large horizontal thrust on the piers, which leads to large cross-section in the main cable and piers supports, more material use, not economical. $L/f \approx 20$.

   b) Big sag has the opposite effect (small cable force and small horizontal thrust on the piers) but requires tall and more costly supports. $L/f \approx 4$.

   c) Optimal span/sag ratio or the normal sag makes the horizontal thrust and piers height and cross-section in an accepted ratio, because of the normal cable force and horizontal thrust and stresses introduced are in the accepted ratio.
   $L/f \approx 10$.



5) There are four basic types of arches:

a) Hinge-less arch: uses no hinges and allows no rotation at the foundations. As a result great forces generated at the foundation (horizontal, vertical and bending forces), it can be built where the ground is stable, and it's a very stiff structure and suffers less deflections than the other arches, so it's economical.

b) Two-hinged arch: uses hinged bearings at foundations which allow rotation. The only force s generated at the bearings are horizontal and vertical forces. Needs stable ground and mostly is steel bridge, allows more deflections than the hinge-less arch but is very economical design.

c) Three-hinged arch: have three hinges, two at the foundations and one at the top of the arch, it suffers very little if there a movement at foundation (due to earthquakès, sinking, etc). Experiences much more deflections and the hinges are complex and difficult to fabricate and it's rarely used.

d) Tied arch: no hinges, it can be used even if the ground is not solid enough to deal with the horizontal forces, the girder itself ties both ends of the arch together thus the name "tied arch" and this deals with the horizontal forces.

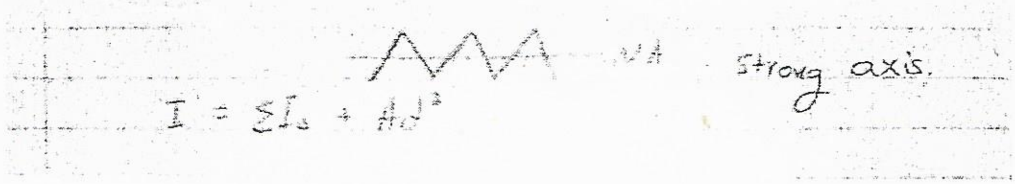
6) The variation is due to the hinges at both sides of the segment, there is no moment exerted at the hinges, and the bending moment various from zero at sides of the segment to max at the mid of the segment, which leads to varies of the cross-section to resist the bending moment.

7) The concept is to reduce self weight by provide the necessary amount of concrete and remove the rest, and keep the strength of the member, and by that we increase the moment of inertia (I) , which leads to increase moment capacity of the beam, and increase stiffness against deflections.

$$I = \frac{b\,h^3}{12} + Ad^2$$

) The correct arrangement is A.

Folded plates meant to resist bending moment by increasing the moment of inertia (I), the figure shows the strong axis in the folded plate. In arrangement B walls are supported the strong axis instead of the weak axis which is wrong.



9) We have one central tension ring and two outer compression ring, steel cables to form the roof with downward slope, thus they are in tension therefore there is a central steel ring to deal with the tension forces, and the concrete compression ring to deal with horizontal thrust, columns to hold up the system and to deal with the vertical forces. Joists between the two rings to transfer and distribute the load between the two rings.

10) The span is limited by the large self-weight and small tensile strength of the stone. Thus we need to minimize the span to reduce the tensile forces causing from bending moment.

11) The member shown is in compression; in compression members we must avoid buckling.

a) Member in compression.

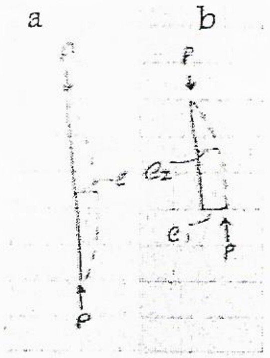
b) Deflected shape caused by buckling.

c) e: distance between original shape and deformed shape.

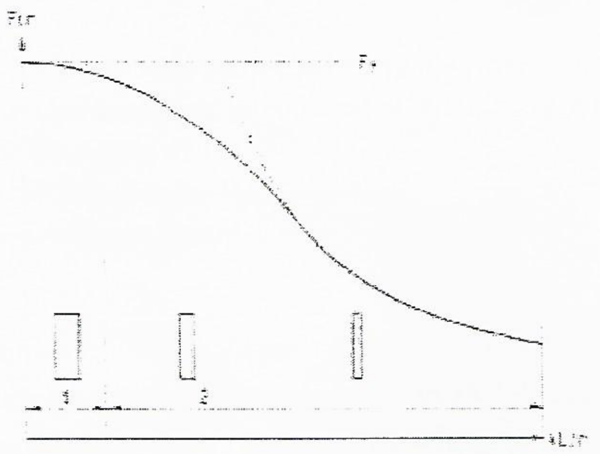
p: compression force.

Bending moment: $M = P * e$

d) $e_1 > e_2$, thus $M_1 = P * e_1 > M_2 = P * e_2$, which leads that the cross-section must increase as we go toward the mid of the column to resist the bending moment.



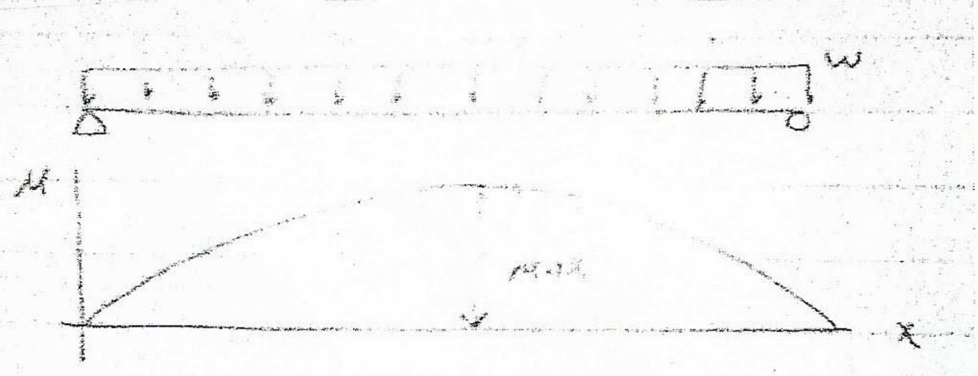
12) **Region 1:** exposed to large force (compression force).
Large cross-section to resist the large compression force and short height to avoid buckling failure.
Region 2: as we go from left to right the critical compression force reduces, as a result the buckling failure decreases, the cross-section of the column can be decreases and we can increase the length of the column.



13) $P_{cr} = \frac{\pi^2 EI}{L^2}$
P_{cr}: Critical buckling load.
We could shorten the length of the column (L) to increase the capacity of buckling load (P_{cr}), or change the cross-section shape to increase moment of inertia (I), or increase the cross-section of the column to increase its carrying capacity.

14) The intermediate piers are exposed to horizontal thrust from both arches from both sides, and they cancel each others, as a result the intermediate piers have to deal with vertical forces only. While both of the ends supports need to deal with the horizontal and vertical forces, as a result they have to be massive to resist these forces.

15) As we can see from the bending moment diagram of the beam it's zero at ends of the beam and increases toward the mid span, so as we move toward the mid span we need to increase the support of the beam to resist the increase of the bending moment.



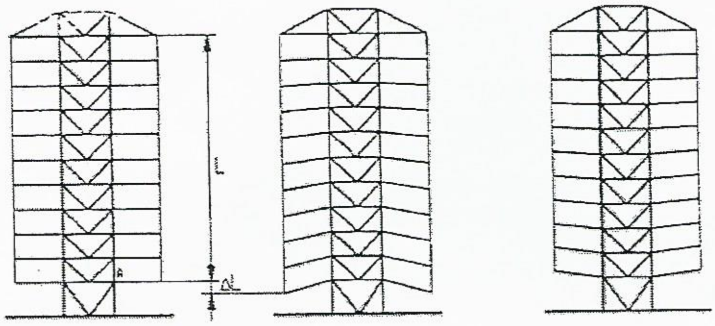
ADDITIONS

1) Thermal Strain: strains and deformations due to temperature changes.

   a- If the member free to deform (elongate or shrink) due to temperature changes, then no stresses are introduced.

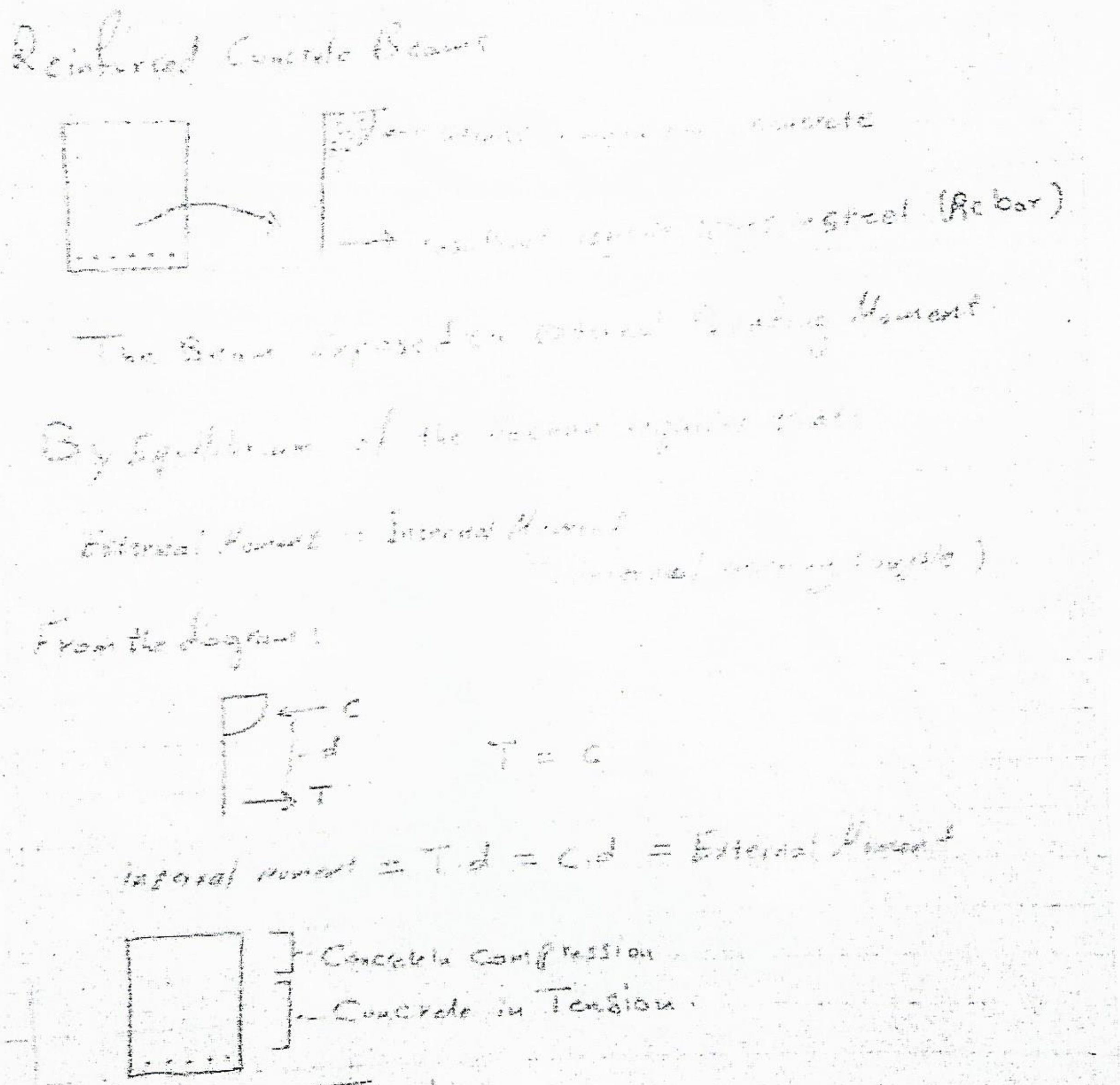
   b- If member is subjected to temperature changes and restrained against free deformation, then stresses are introduced in it. And these are significant stresses which must be accounted for by means of :
   1- Strengthening the member
   2- Expansion joints

2) Cables can only hold axial forces, so its subjected to axial stresses and strains and deformations, which exposed it to elongate, and these elongations must be accounted for by evaluating the difference (ΔL) in length between loaded and unloaded cable.
   Remember this example:



3) See Question 8.

4) Beam basic equation: $\sigma = \frac{My}{I} \leq \sigma_{allow}$
   Design format $I_{req} \geq \frac{M_{max} \cdot C}{\sigma_{allow}}$
   The larger the bending moment the larger the deflection, the larger I_{req}, the larger the cross-section, larger self-weight, which leads to larger the portion of beam capacity to carry load consumed by self-weight which makes not efficient.



✱ Concrete in Tension:

a) Provide leaver arm for the internal couple.

b) Provide depth to secure sufficient stiffness (I).

c) Provide bond with rebar.

d) Resist shear.

6) About Seismic Load:

Earthquakes cause horizontal and vertical ground shaking. The horizontal (lateral) shaking is usually most critical on buildings. This lateral forces called Base Shear, it cause foundation damage which leads to failure of the building, to avoid or to resist base shear we need to make our building more ductile. Ductile material (structures) deform and back to its original shape, yet brittle structure sustain great interior forces cause it to crack. Vertical shaking adds loads on the building which mostly can be resisted by the structure elements of the building.

7) It's known as post-tension because the steel reinforcing is tensioned after the concrete is placed, and the tightening of the reinforcing bars to compensate for the shrinkage of concrete.

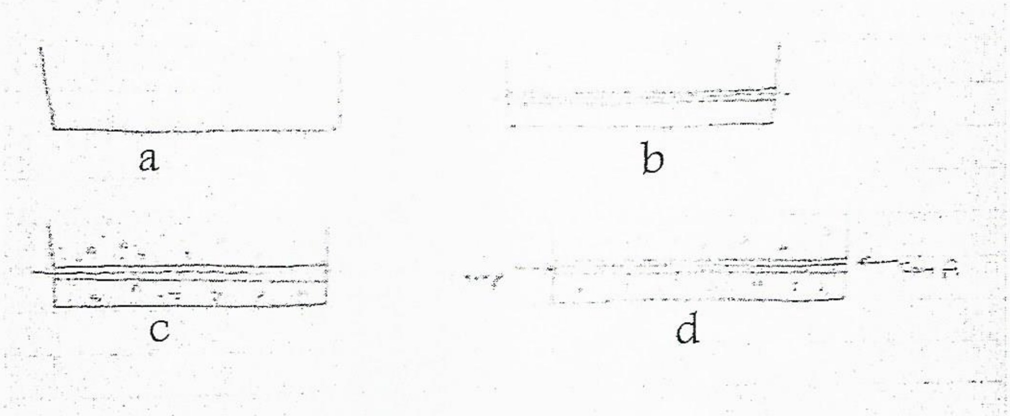
How it's done:

a) Install the frame work needed.

b) Install conduits and strands as required by design.

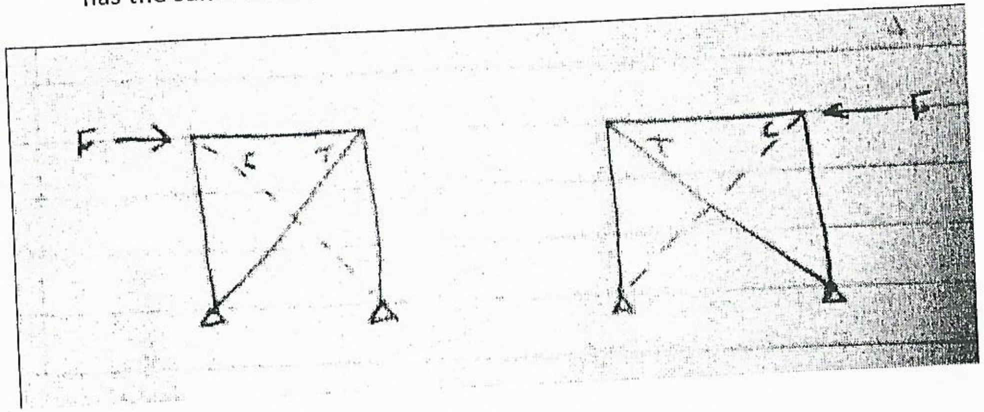
c) Pour fresh concrete.

d) After concrete attains certain strength install and tension steel strands, install plugs, cut off strands and inject concrete into conduits.

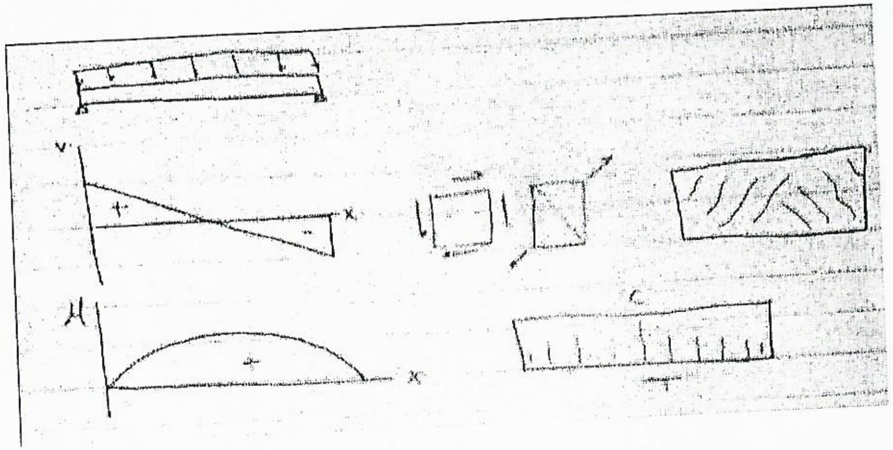


Midterm

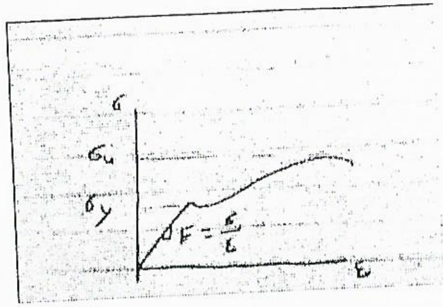
1- Bracing resist lateral loads. To avoid providing large section for the compression diagonal subjected to buckling, we ignore it and rely only on tension diagonal. Thus, each single diagonal resist the load and ultimately has the same cross section.



2- As we see in the figure cracks formed from shear usually are inclined cracks various from large cracks on the sides to small in the mid as the shear diagram refers. Cracks formed from bending are normal cracks to the axis of the member and it happens toward the tension side in member.



3- It's the property given by stress – strain diagram (subject material to load), usually has to do with the ability for the structure to act under certain loading.
Ex: σ_y , E.



4- Geometric property is calculated from the cross section of a member.
Ex: I, J, r, Q.

5- Forces, stresses and deformations resulting from loading.

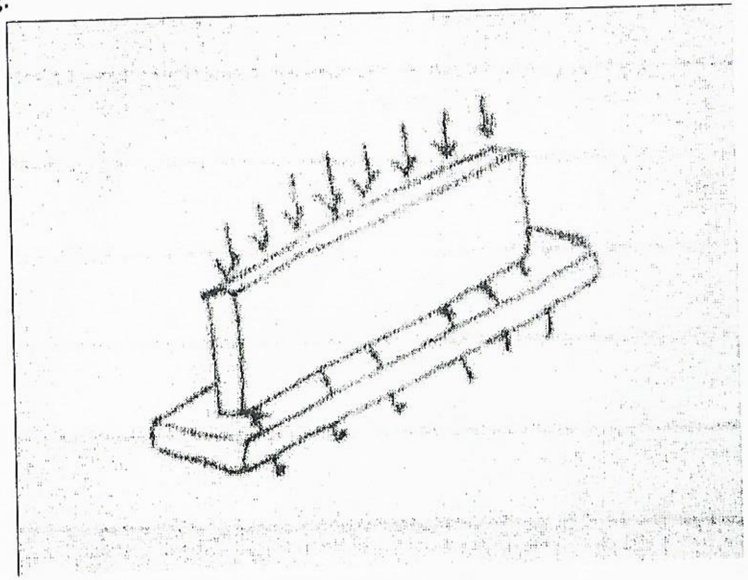
6- Strength criteria: Design a structure member such that no failure made (yield, buckling) takes place under designed load.
Serviceability: Design a structure member so that it performs its intended function a appropriately in terms of deflection, vibration in code of IBC.

7- (a) Stresses in bearing wall are low due to the fact that it's carrying the load through its cross-section and its cross-section is relatively large, so:

$$\sigma = \frac{P}{A}$$

(b) 1- Bearing capacity of soil is weak (much weaker than the wall material), so its need larger bearing areas.

2- The concept of bearing requires continuous contact between wall and footing.

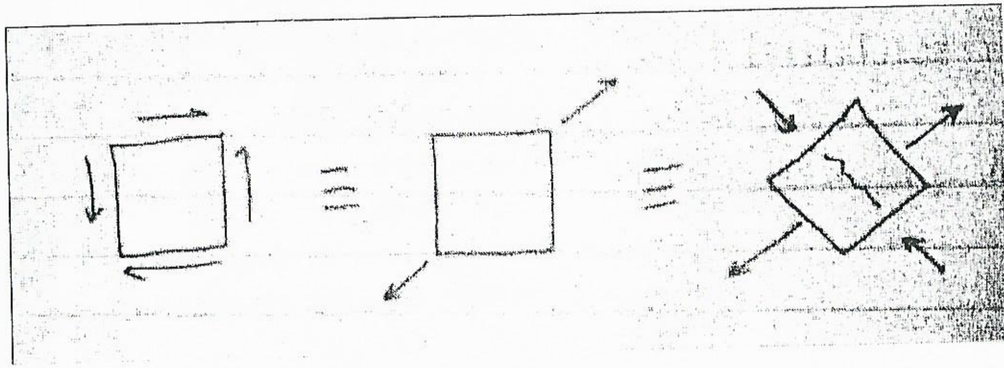


8- (a) Its variable due to the variable of internal bending moment, its low in the sides and zero on the pins, and become larger in the mid.

(b) A frame with 3 hinges supports is unstable, so side ties are required to secure stability and resist lateral load action.

9- When wind load acting on a structural building the wind load acting on the wind wall which transfer load to the diaphragms, and then the diaphragms transfer load to shear wall then the shear wall transfer wind load to the footing foundation so the path load: wind wall > diaphragms > shear wall > foundation.

10- This is a shear force crack that occurred due to tension in a 45 angle to the horizontal.



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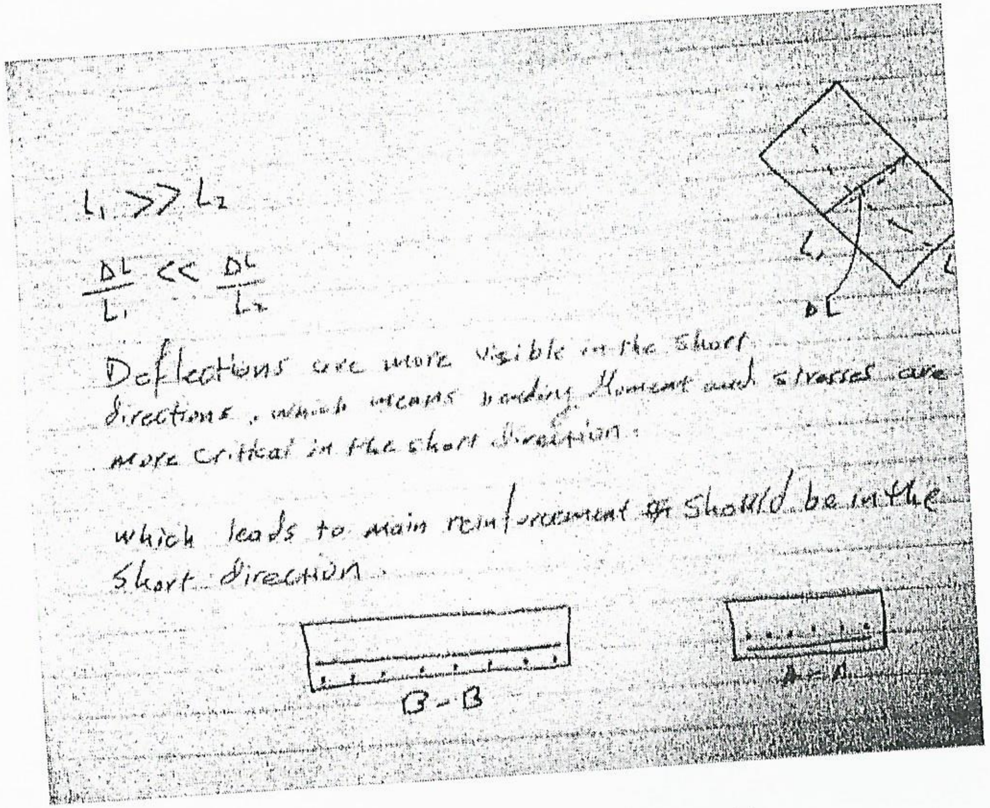
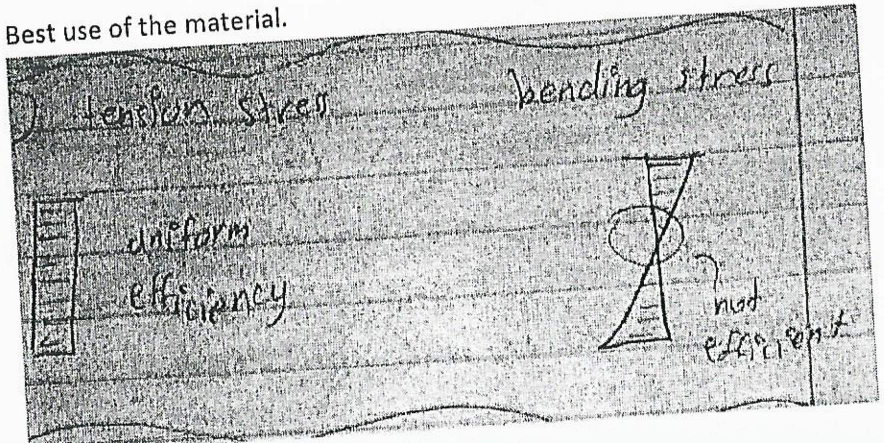


12- Provides lateral support against lateral torsional buckling of beam.

13- Best use of the material.



14- It's a storey consists from columns only to provide max space, and so it doesn't resist lateral loads which provided by shear walls.

15- $\phi < 1$, it's a strength reduction factor take account of discrepancies in material, properties, members dimension.
$\gamma > 1$, load magnification factor to increase safety in design.

ADDITIONS

1- (a) Bearing wall system: foundation along the length of wall to transfer loads to the ground.
(b) Skeletal system: composed of slender member (beams, colum
through which loads are transferred to the foundation.
(c) Plate and Shell structure: thin in cross section, continuous curvature, internal forces are mainly compressive.
(d) Membrane: self bearing system to provide protection.

2- **Loads:** dead loads, live loads, snow loads, wind loads, earthquakes loa
hydrostatic loads.
Load path: The path that a load travels through the structural system.
Tributary area: Loading area assigned to a specific structural member
Truss: Straight elements connected at joints (which behaves as p
form a set of triangles (simplest staple geometry) and loads are
applied to the joints, this result in axial forces (T/C) in truss mem
Bearing tress: Normal stress acting on the contact surface betw
elements transferring load to each other. Ex: foundation, footi
soil.
Shear wall: Solid wall meant to resist lateral forces acting on t

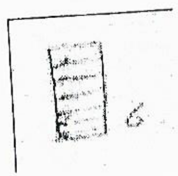
structure by means of shear resistance.

3- (a) Frames action (rigid frames), connection between beams and columns are rigid moment connections, takes care of both lateral and gravity loads.
(b) Simple frames: by shear walls or bearing system.

4- Beam: (a) Geometry: span much larger than any other dimension of cross section.
(b) Function: mainly resist bending + shear.
(c) Loads: applied transversely to its longitudinal axis (axial force usually).

Slab: (a) $L_1, L_2 \gg t$
(b) Function: mainly resist bending + shear.
(c) Loads: applied transversely to the plane of slab.

5- Truss system or cable system has only one internal force (C/T) this result in uniformly stresses distribution acting on the member, so we can efficiently use the material, this leads to well designing of the section, and this result in minimum cost so it's economical.
Stress distribution in truss member:



6- In Two-way slap, $L_1 \approx L_2$ or $\frac{L_1}{L_2} < 2$, so relative deflection in L_1 direction is equal to the relative deflection in L_2 direction, which means bending moment in both directions are important, which means reinforcement must be provided in both directions.
But bending moment in the shorter direction is larger than the other, so reinforcement in the shorter direction should be placed further to provide larger leaver arm between compresses concrete and tensile reinforcement, so larger resisting of moment.

7- It's ok. But we didn't use the reinforcement in sufficient way.

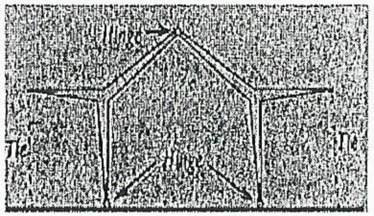
8- Main reinforcement: meant to resist bending moment in slabs and beams.

Non-main reinforcement: 1- To resist shrinkage and control cracks.
2- Arrangement of bars.
3- To provide ductility.

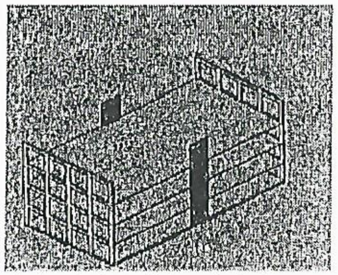
Mechanics/cl...

Midterm

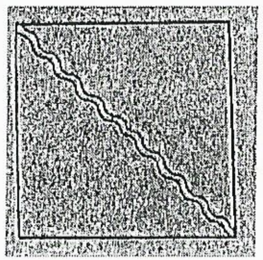
1. Bracing diagonals always have the same shape and cross section!
2. How do we distinguish cracks caused by bending from those caused by shear in concrete beams? Explain!
3. What is mechanical property of material? Give an Example.
4. What is geometric property of a section? Give an Example.
5. What do we mean by the expression "behavior of structural member"?
6. Design of a structure is supposed to satisfy two major criteria: strength and serviceability. Explain!
7. (a) Stresses in bearing wall are relatively low!
   (b) Bearing walls require continuous footing beneath them!
8. (a) Explain why the profiles of the structural members shown in the figure is variable.
   (b) Explain the necessity of ties at both ends of the structure?



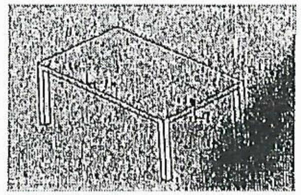
9. Explain the purpose/role of the shaded and the frames on the side of the building shown in figure.



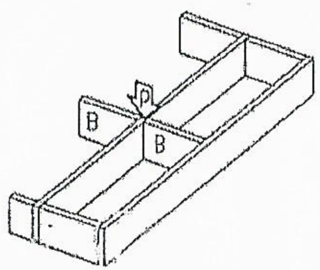
10. Explain how the diagonal crack took place in the wall shown in the figure.



11. The figure illustrates reinforced concrete solid slap. Draw the cross section *A-A* and *B-B* showing the main reinforcement bars. Explain your arrangements of the bars.



12. Explain the main role of element B in the figure shown.



13. Tension members are highly efficient when compared to flexural members.
14. What is "soft story" in multi tory building?
15. What is the role of and in the design equation $\phi R_n = \gamma Q$

ADDITIONS

1- Structural systems.
2- Define ***Loads, load path, Tributary area, Truss, Bearing stress, Shear wall***
3- How structures resist loads?
4- Slab is actually a beam. Explain!
5- Why is, truss system or cable system or any system (has only one kind of internal forces), is an efficient or economical system?
6- How ***Two-way slap/action*** should be reinforced. Explain!
7- What happens if we didn't put the main reinforcement in the critical direction?
8- What is the difference between ***main reinforcement*** and ***non-main reinforcement***?

Mechanics/structure
عمارة

FINAL STRUCTURE

1) Explain why the elevated arches, such as the one shown below, are almost always of the same type "tide arch"!

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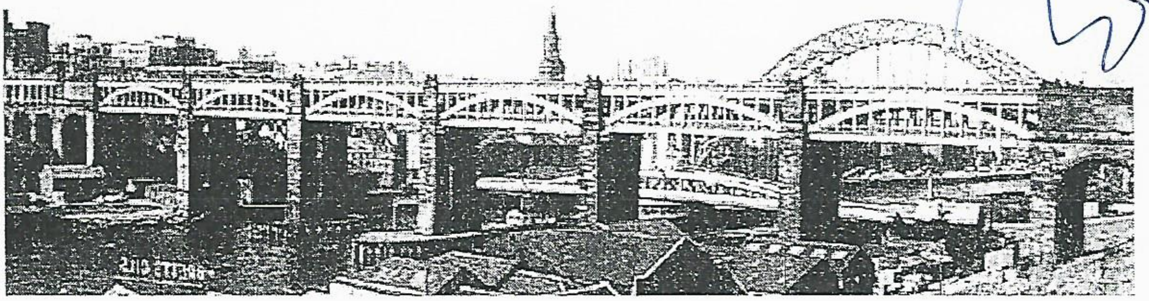

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