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HEAVY MOVABLE STRUCTURES
MOVABLE BRIDGES AFFILIATE

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"Bascule Bridge Activated By a Cable System", L. Nedelcu,
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BASCULE BRIDGE ACTIVATED
BY A CABLE SYSTEM

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INTRODUCTION

The intersection between a roadway or a railroad and a waterway, requires a bridge structure. If the waterway is navigable and the structure has a limited vertical clearance, some kind of movement for a section of the bridge structure to permit passage of the vessels is necessary.

The portion of the structure can be displaced in both vertical and horizontal plans. For structure motion there are also two possibilities, translation and rotation.

The combination between the plan of displacement and the type of motion leads to four general categories of movable structures:

1. vertical translation
2. vertical rotation
3. horizontal translation
4. horizontal rotation

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Fig.1 Movable Bridge in Vertical Plan

a. translation motion b. rotation motion

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Fig.2 Movable Bridge in Horizontal Plan

a. translation motion b. rotation motion

Fig.1 depicts schematically a movable structure using the vertical plan for displacement, and Fig.2 depicts schematically a movable structure using the horizontal plan for displacement. The movable structures using the vertical displacement combined with the translation motion are known as vertical lift bridges

and usually are used for big spans.
The most common movable structures are the ones using the vertical plan for displacement in combination with the rotation motion which are known as bascule bridges.
Swing bridges are movable structures using the horizontal plan for displacement combined with the rotation motion and used to be the favorite category in the first half of the century.
The less popular movable structure are the ones using the horizontal plan for displacement and the translation motion.
A movable bridge can change its positions several times per day, changing its static scheme.
From the structural viewpoint the vertical lift bridge is simple supported in the closed and open positions. In the open position the movable structure is suspended by cables from high towers.
In the closed position the bascule bridge is either simple supported (single leaf) or cantilever (double leaf) and in the open position the structure is cantilever bearing on trunnions and the live load bearings.
In the closed position the swing bridge is either continuous or simple supported and in the open position is a cantilever structure.
The changes in the static scheme affects the stress diagram from open position to closed position requiring a laborious structural analysis for the movable bridges.
In each of the four categories there are different approaches for the operating system of the bridge but the most common operating systems are either mechanical system or hydraulic system.

BASCULE BRIDGES

There are approximately 2,200 movable structures in the USA, from which 840, that is 40% from the total, are bascule type. Considering the rotation procedure the modern bascule bridges can be divided in two classes: rolling type and trunnion type.
Sherzer patent is the most representative operating system for rolling lift bascule bridges.
The trunnion type bascule bridge, which is the most reliable structure, can be operated either by a mechanical system or by a hydraulic system.
Strauss patent is the most representative system for the trunnion type with a gear assembly activated by an electromechanical device.
The hydraulic operating system consists of pistons applying a pushing force in the front of the trunnions and is the designer choice for the modern bascule bridges.
The center of gravity of the movable structure should be at or near the axis of the rotation, resulting in a small torque for operating the movable structure. Due to a precarious equilibrium, rebalancing the movable structure represents a challenge for the maintenance personnel.
The span of the movable structures is limited by the capacity of the hydraulic pistons.
Regarding the structure, improvements in the structural design of modern bridges led to lighter movable structures. The new structures features orthotropic steel plate decks bearing on

floor beams which further transfers the applied loads to the main girders.

BASCULE BRIDGE ACTIVATED BY A CABLE SYSTEM

USA Patent and Trademark Office has granted the patent No. 4,751,758 for a bascule bridge activated by a cable system. The new system is of trunnion type and uses pulling forces for the movement of the structure applied at the back of the trunnion instead of pushing forces in front of the trunnion used for the hydraulic systems.

[Figure missing from original document.]

Fig.3 Bascule Bridge with a Cable System.

a. close position   b. open position

It should be noted that for a similar pier width, the arm of the pulling force applied in front of the trunnions can be several times bigger than the arm of the pushing force applied at the end of the counterweight.

With a bigger arm the system is capable of a larger torque being more reliable and significantly less affected by the balance of movable structure.

Fig.3a shows the bascule bridge activated by a cable system in close position and Fig.3b shows the bascule bridge activated by a cable system in open position. In the close position the structure is pinned at the end of the counterweight and bears on trunnions, eliminating the need for the live load bearings.

In the open position the structure is released form the pin and a pulling force is applied at the end of the counterweight rotating the bridge structure about the trunnions. During the rotation, particulary at the limit of the opening, the bridge structure is guarded against wind forces by the other end of the cable which is attached in front of the counterweight at its lower part.

[Figure missing from original document.]

Fig.4 Bascule Bridge with a Cable System. Cross Section

a. longitudinal ribs b. transverse ribs

The cable is wind on a spool which is activated by an electric motor. Damping devices capable of absorbing shock energy, if the cable system fails, are provided on pier walls. Two alternates of the bascule bridge structure activated by a cable system are shown in Fig.4. Both cross sections feature orthotropic steel deck plate with a double rib system, and three main girders which makes the system redundant.

The first alternate consists of floor beams which transfers the loads from the orthotropic deck to the main girders. The ribs of the orthotropic deck are longitudinal orientated giving a good torsion rigidity of the system. This alternate requires a large quantity of welding and the field splices of the bridge structure are quite complicated.

In the second alternate the ribs transfers the loads from the the orthotropic deck directly to the main girders. The ribs of the orthotropic deck are transverse orientated, requiring a more complex bracing system of the bridge structure.

This alternate requires a smaller quantity of welding and there are field splices only in the main girders.

The concept presented for the new movable structure can be easily applied for the rehabilitation of the old bascule bridges.

The existing movable structures are aging with some of them built at the end of the last century. Usually the old movable bridges ar truss type structures, using a fair amount of structural steel. The problem with the old bridges are associated with corrosion of the steel structure and with the slow motion due to an old operating system having many moving parts.

Where the substructure is in good condition, a new lighter superstructure activated be the cable system can be the answer for the rehabilitation of the old structures, and Fig.5 shows a tentative scheme for the rehabilitation of the East 92th Street Bridge in Chicago.

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Fig.4 East 92th StreetBridge. Rehabilitation Alternate

CONCLUSION

The old movable bridges are difficult to maintain and operate. Highway traffic volumes combined with maintenance and operating difficulties makes the movable bridges less attractive to the owners and designers.

These are the tow main reasons the number of movable structure are decreasing every year, being replaced by high level bridges. The bascule bridge with a cable system presented in the paper can be a reliable solution to the new movable structures. The new concept for the operating system combined with a orthotropick steel plate with double rib can reduce the weight of the structure, the maintanance cost and the time cycle of the opening, increasing the volume of traffic.

APPENDIX - REFERENCES

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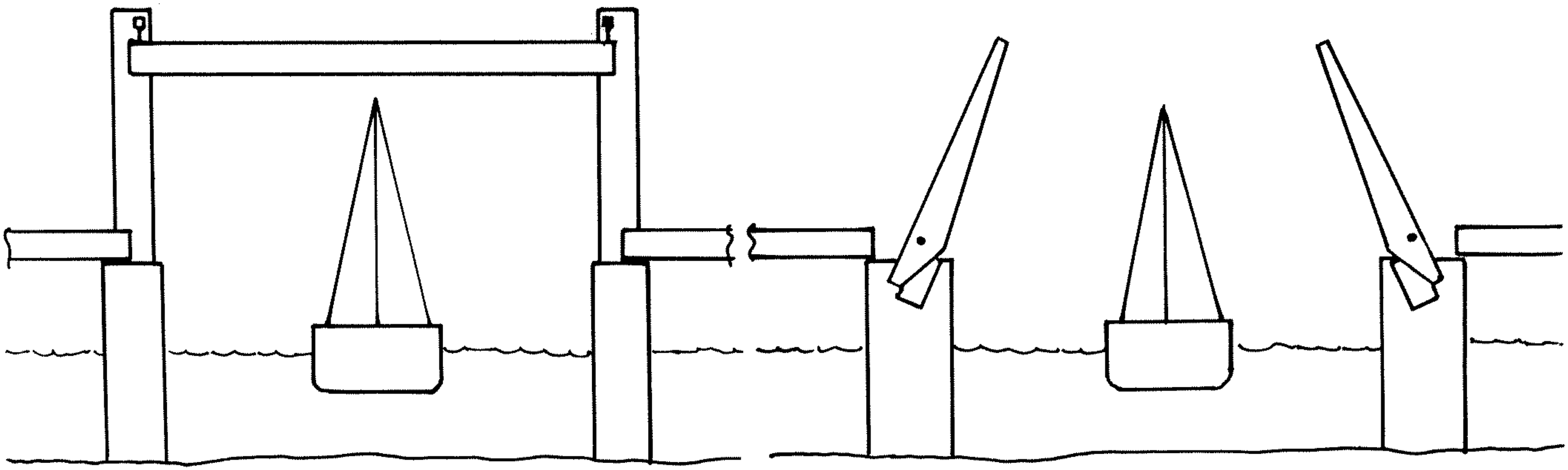
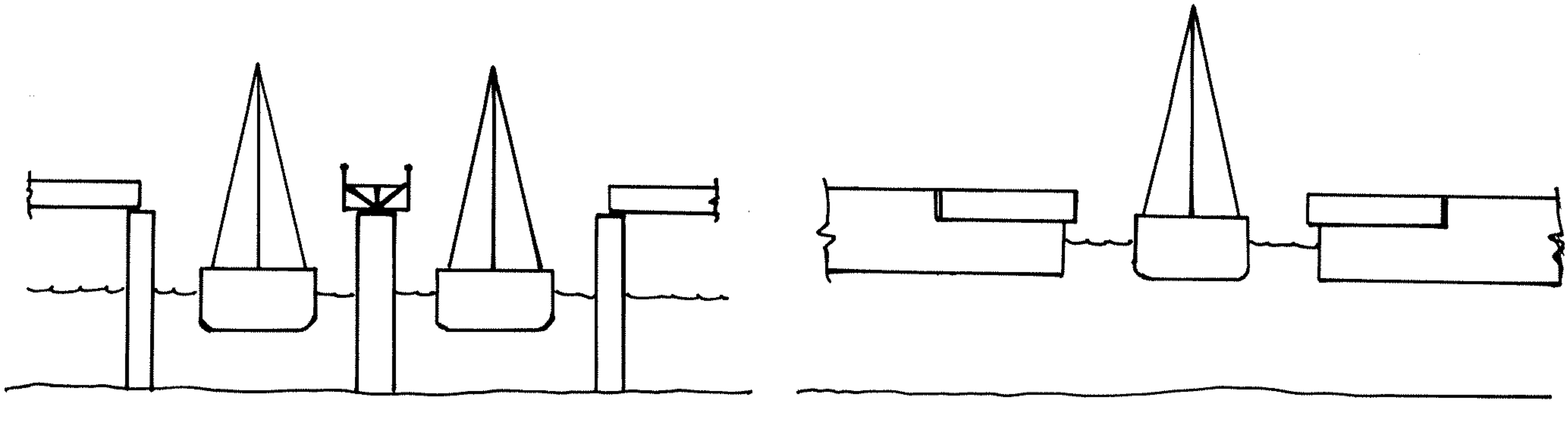


a

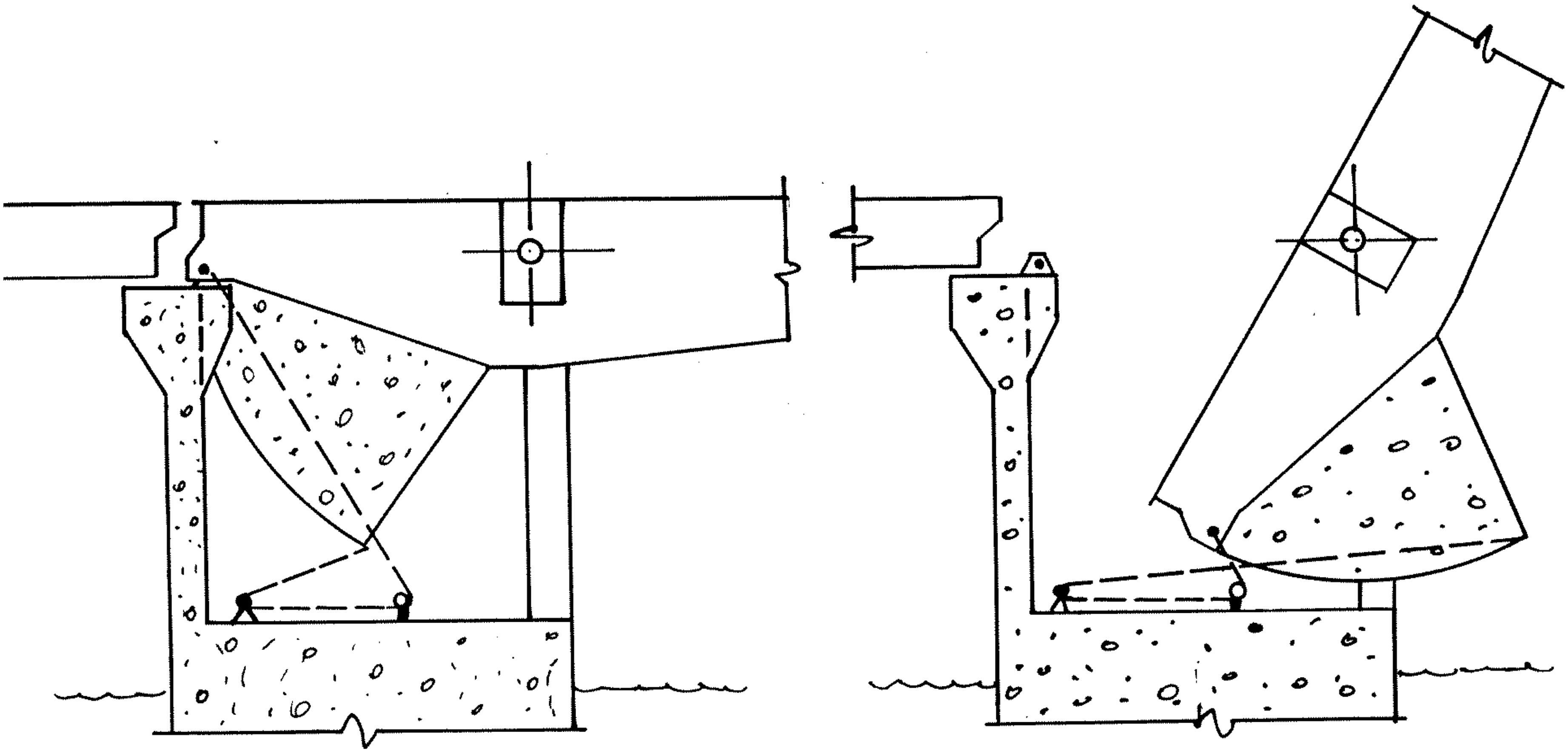
b

fig. 1



a   b

Fig 2



a

b

fig 3

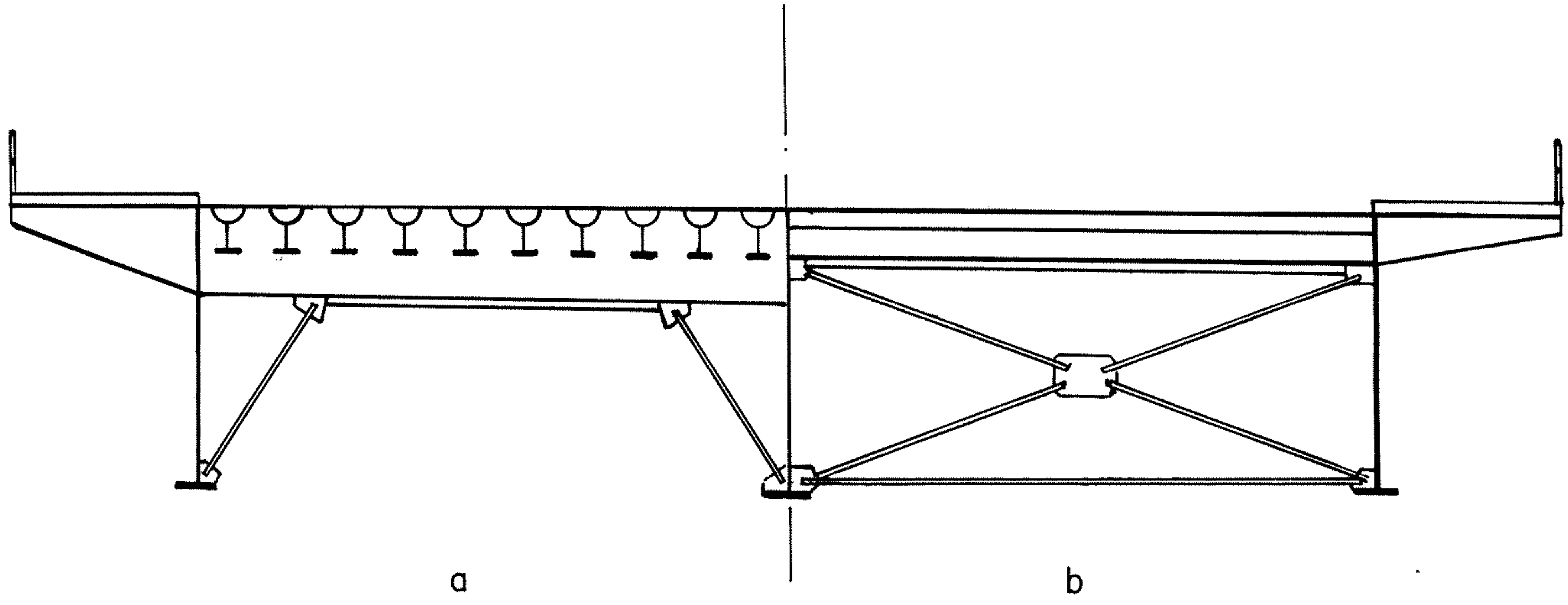


fig 4

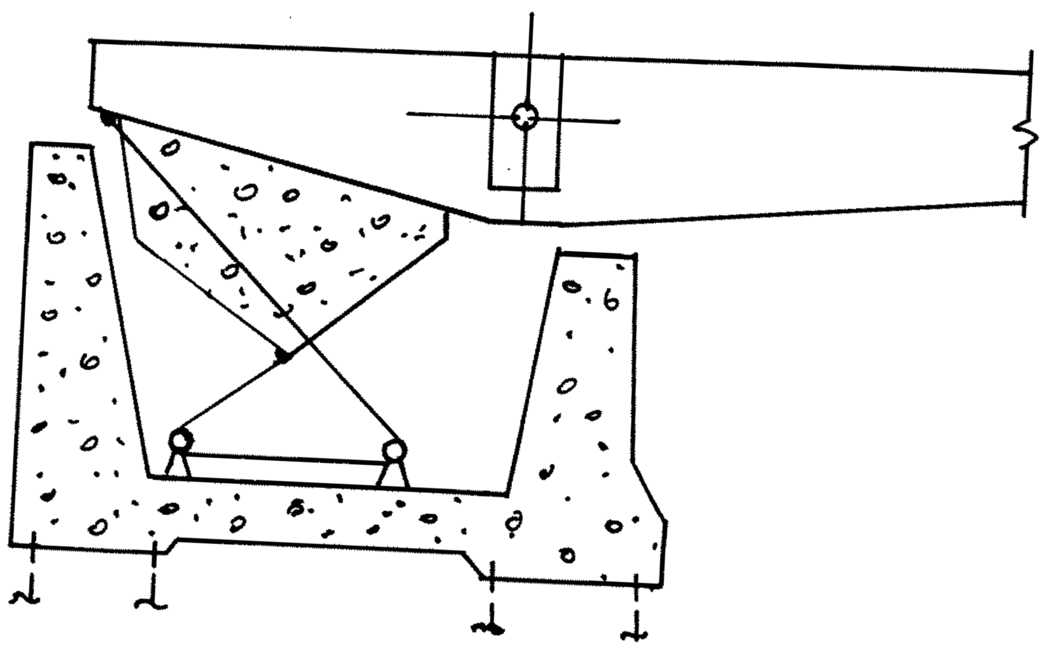


fig 5.