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Special Method of Well Sinking Adopted at New Nizamuddin Bridge on National Highway-24 in New Delhi

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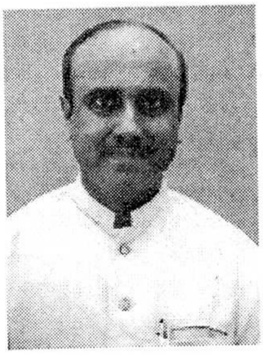

Born on the 21st July, 1945, graduated in Civil Engineering from M.B.M. Engineering College, Jodhpur in 1968. He started his career with Delhi Municipal Corporation. Later, he joined the International Airports Authority of India. He is Founder Member and Secretary, Association of Airport Planners and Engineers (India). He was Vice-President, Indian Roads Congress, 1991-92, and again he was elected as its Vice-President for 1997-98. Recently, he has been elected as Vice-Chairman of Consultancy Development Centre, New Delhi.

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Born on 1st January 1939, did his Bachelor of Engineering (Civil) from University of Roorkee, India in 1961. Since almost the beginning of his career, he has been engaged in execution of a number of bridge projects both in India and abroad. On behalf of ICT as domestic consultants, he was responsible for execution of Second Nizamuddin Bridge in New Delhi.

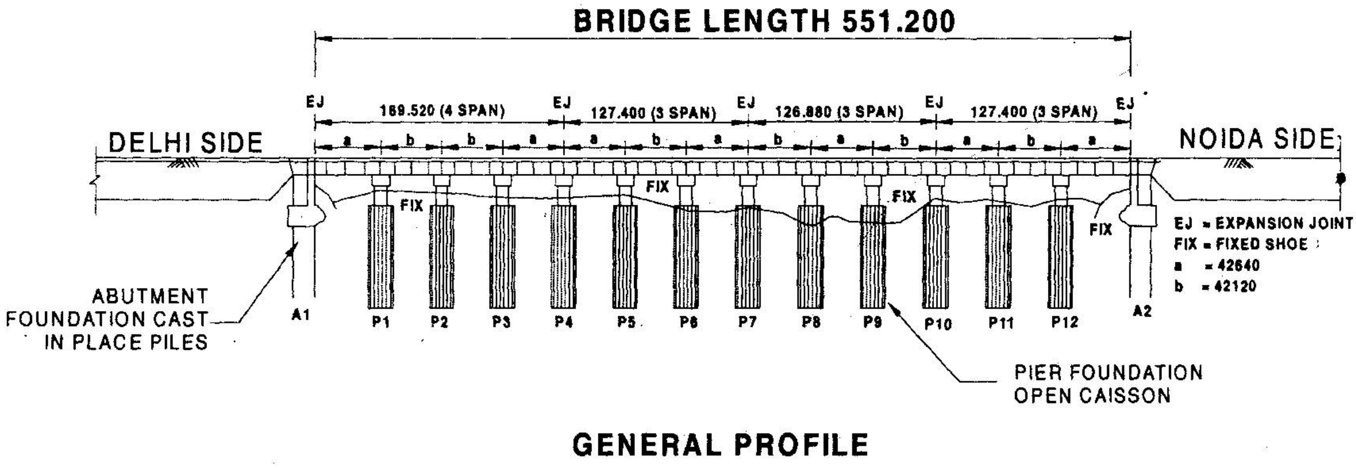
SUMMARY

The Paper deals with the special technique adopted for sinking of well foundations in the new Nizamuddin Bridge in Delhi. Sinking of wells by conventional method has long been adopted in construction of bridges in this country. In conventional method, the sinking is being done by dredging the sub-soil material from inside the well and the well would sink automatically by its own weight. Quite often, kentledge loads had to be applied on top of the steining to put extra weight for sinking along with dewatering from inside the well, water as well as air jetting along the periphery of the well steining. This was quite a slow and cumbersome process. The Japanese consultants and the contractors adopted a new technique in sinking of the well foundations, which has been adopted for the first time in this country. In this process, external load was applied on the well steining with the help of soil anchors and hydraulic jacks and simultaneous dredging of the material from inside the well. This process resulted in fast sinking of wells and this helped in saving of time and cost. This Paper describes mainly this specialised method of sinking.

1. INTRODUCTION

The New Nizamuddin bridge along with its short links on National Highway-24 over river Yamuna in New Delhi, the capital of India has been constructed under Japan Grant Aid scheme of the Government of Japan through Japan International Co-operation Agency (JICA). Detailed engineering of the project was carried out by M/s Nippon Koei Co., Ltd in association with Katahira Engineering International, Japan. They were also the supervision consultants of the project, Employer of the Project was Ministry of Surface Transport, Government of India. The work was supervised by Public Works Department, Government of Delhi on behalf of Ministry of Surface Transport. M/s ICT (Pvt.) Ltd. were the domestic supervision consultants with M/s Nippon Koei. The Project was executed by M/s Obayashi Corporation of Japan with M/s Engineering Construction Company (ECC) of M/s Larson & Tubro Group as their sub-contractors.

The bridge is 551.20 m long with 13 spans of 42.4 m (average) each c/c of bearings with short link approaches of 359.8 m on Delhi side and 419.2 m on Noida side. The width of the bridge is 22.6 m (end to end) consisting of 4 lane carriageway of 15 m with 3 m wide cycle track on either side. The superstructure is prestressed concrete precast multiple I girders (10 Nos per span) with RCC deck, having one unit of 169.52m of 4 spans with connection girder, one unit of 126.88 m and two units of 127.4 m of 3 spans each with connection girder. There are 12 Nos of wall type piers, 7.4 m to 8.3 m in height supported on RCC caissons. The abutments are 8 m high RCC wall type. The abutment foundations rest on cast-in place RC piles (18 numbers, 1 m diameter and 24 m deep). A general profile, and details of the proposed bridge (typical cross section) are shown in **Fig. 1.** The work was started in February 1996 and completed in Feb. 1998.



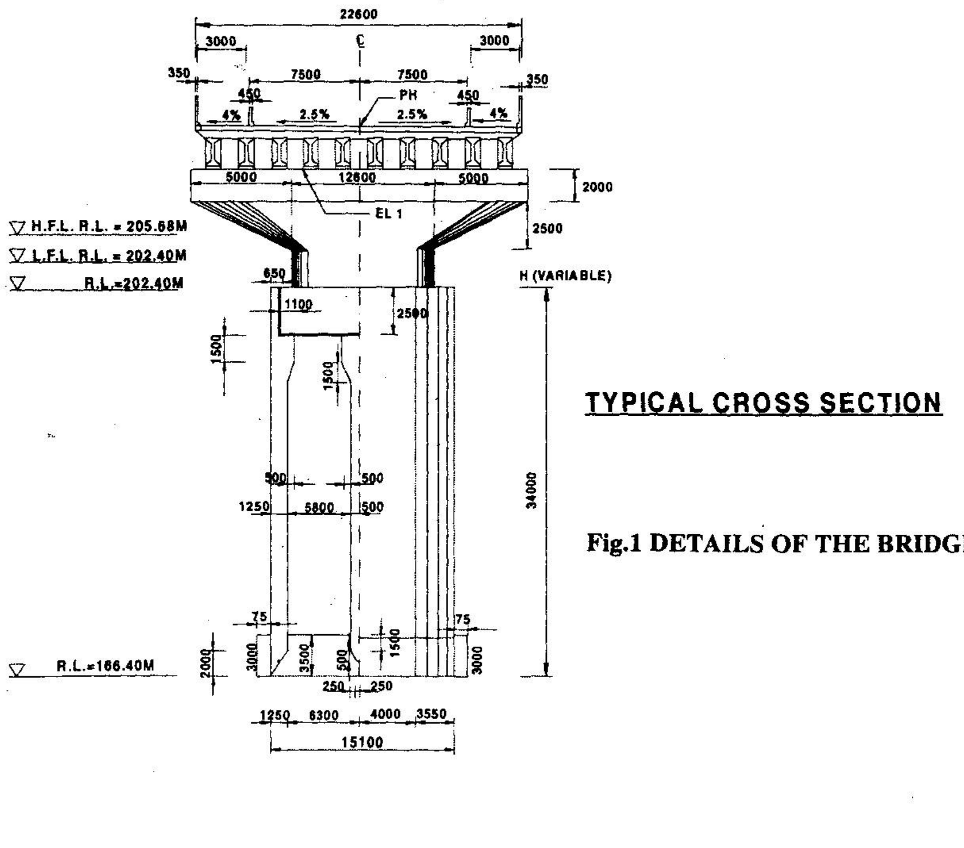
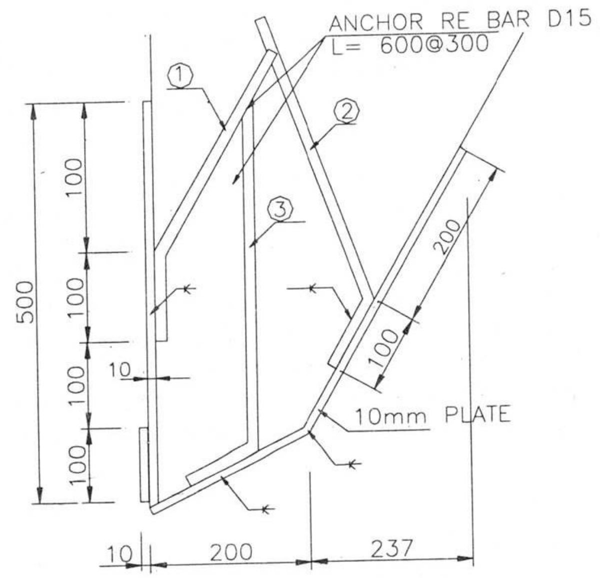


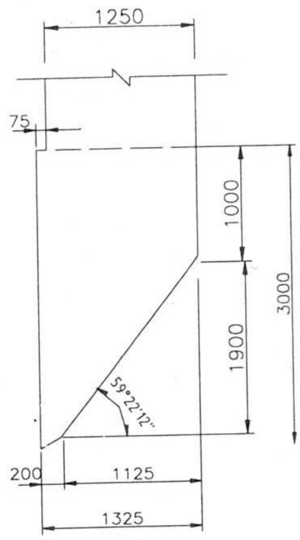
Fig.1 DETAILS OF THE BRIDGE

2. SIZE AND SHAPE OF CAISSON AND SUB SOIL STRATA

Oval shaped, double D type caisson foundations with overall size 15.10x7.10 m having 1.25 m thick RCC steining and a central diaphagrm of 1 m width in M-30 concrete have been provided. Caissons are 34 m deep below top of well cap. Well curb is 3 m high with 75 mm projection on outer face of steining. The inner face of curb has an inclination of 59° 22' 12". Cutting edge provided below the curb is made of steel plate as per shape shown in **Fig. 2**. **Photo 1** shows cutting edge in position and **Photo 2** shows sinking of caisson in progress.



Details of cutting edge



Details of curb

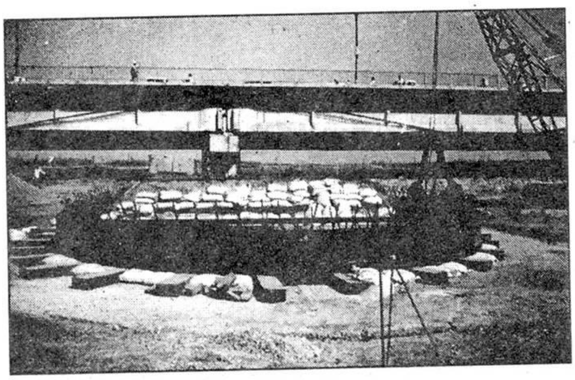


Photo 1 : A close view of cutting edge in position

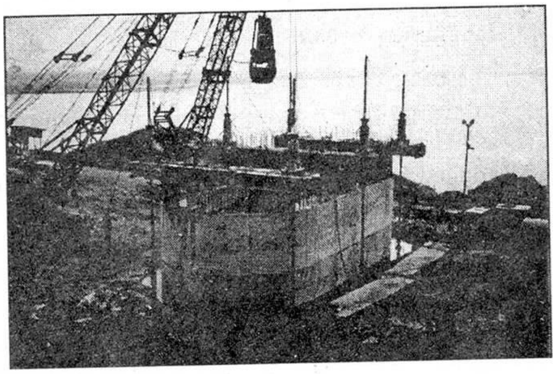


Photo 2 : A view of sinking of caisson in progress

Sub soil strata varies from fine sand at the top to clayey silt at the foundation level having silty sand and silty clay layers in between.

3. SPECIAL METHODS ADOPTED FOR SINKING

3.1. The following special methods for sinking of caissons were adopted individually or in combination as per site requirement depending upon the strata met during sinking.

3.1.1. Air jet method

Air jetting is a normal method used for reducing the soil friction on the outer periphery of caisson to facilitate the sinking. On this project, Air jetting system was adopted in a very different and effective manner so as to work all around the caisson periphery at the same time. It also provided scope to increase or decrease the area and extent of air jetting to suit the site requirements. In this method, PVC pipes were left on periphery of steining just touching the surface of formwork in first four lifts of steining after casting of curb. Rubber flaps were fixed on the pipes at 1 metre interval all along its length. After concreting and removal of formwork, 4 mm dia holes were made in PVC pipes and rubber flaps were fixed which were normally visible at the concrete surface. These holes act as nozzles during air- jetting whereas the rubber flaps protected the choking of these pipes. The pipes of each row were carried right up to the top in subsequent lifts of the steining.

When compressed, air is blown from compressors through these pipes, air penetrates in between the soil mass and the concrete surface and reduces the frictional resistance on the surface all along the periphery. Intensity and extent of air jetting can be controlled by operating one or more rows of pipes at a time or even on one side of the caisson. Normally, four horizontal rows in the lower portion of caisson are sufficient to loosen the soil around and above the curb portion which offers maximum soil resistance during sinking.

Air jet method works very well in cohesive soils. Pressure of air at any stage of sinking is kept 50% more than the water pressure at the bottom of caisson. Maximum air pressure is normally kept within 7 kg/cm^2. One or more compressors of 200 to 300 Cfm capacity are required for air jetting preferably with an air tank of 5 to 10 cu.m. capacity depending upon the site condition. Air tank should be capable to withstand a pressure of at least 8 kg/cm^2. Air Jetting alone was quite effective in early stages of sinking but was generally used in combination with jack-down method at deeper depths. It has been observed that by air jetting, frictional force on the outside surface of steining is reduced up to 20% of the anticipated load required for sinking the caisson. These pipes were later used for cement grouting of soil mass around the caisson after bottom plug to restore the soil friction around the caisson in the bottom portion below scour level.

3.1.2. Water jet method

The water jet method is used for cutting hard soil from inside the caisson and to remove soil below and around the curb and cutting edge portion. During dredging operation, the soil below and around the cutting edge and curb does not get removed specially in case of cohesive soils and hard strata. This soil is cut by high pressure water jet at a pressure of 100 to 150 kg/cm^2. It makes cutting edge free and allows the caisson to sink. This method is very effective in clay or hard strata, either alone or in combination with air jetting and Jack-down method.

3.1.3. Jack-down method

The basic concept of Jack-down method is to push down the caisson into the ground by applying load from top of the steining through jacks which take reaction from soil anchors. Soil anchors are first made at the predetermined locations in the bed as per requirement along periphery of the wall and load is applied by jacks through fabricated steel girders which are placed on top of steining. The load to be applied by jacks depends upon the size, shape and depth of caisson and the subsoil strata. The jacks are operated individually or collectively and load on each jack can also be varied to control the tilts of caisson during sinking. The soil anchors are basically friction piles and are designed to take reaction of jacks. However, friction is considered only in the length of anchors below final founding level of caisson. Soil friction around caisson is reduced by air jetting and soil below cutting edge and curb is excavated by water jetting as and when required. System is very clean, fast and effective and sinks the caisson in true vertical position with controlled tilts, shifts and rotation. Arrangement of Jack-down method as adopted at site is shown in **Fig. 3.**

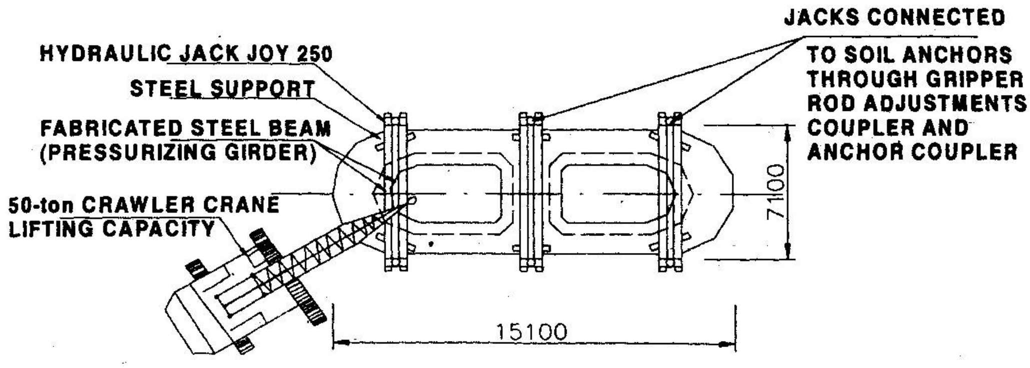


Fig. 3 : Arrangement of jack down method

The pressure on caissons were applied by six jacks of 250 Tonnes capacity up to a maximum load of 1200 Tonnes. The pressurization mechanism is shown in **Fig.4.**

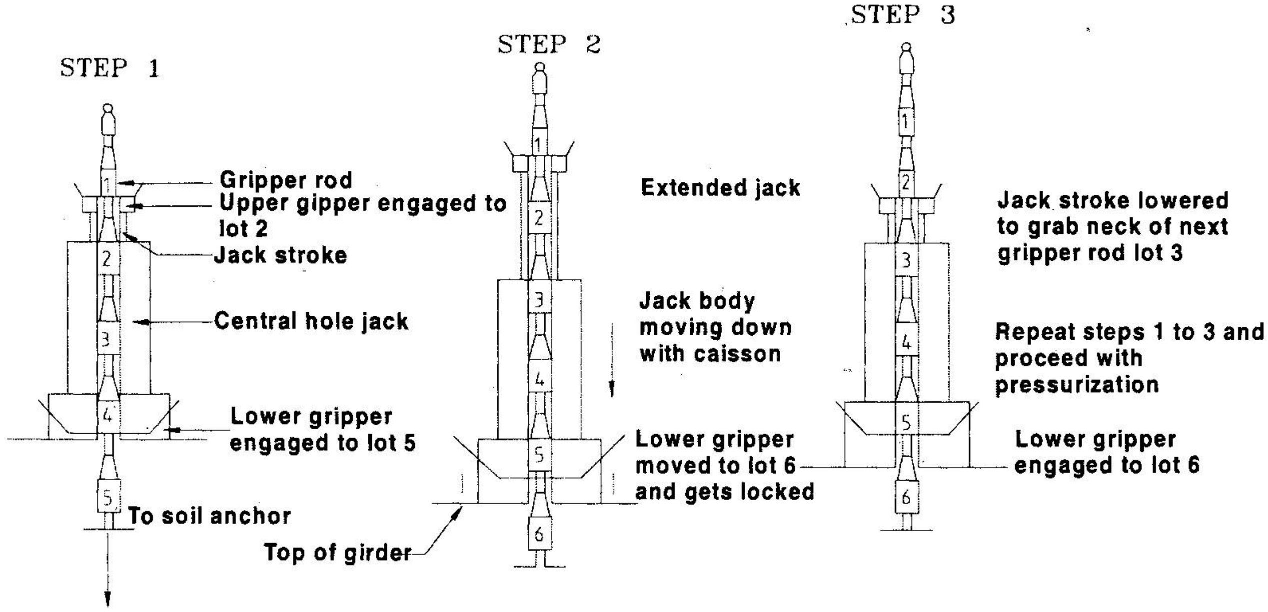


Fig. 4. Pressurizing mechanism to jack down the caisson

Jack down method consists mainly of the components as shown in **Fig. 5.**

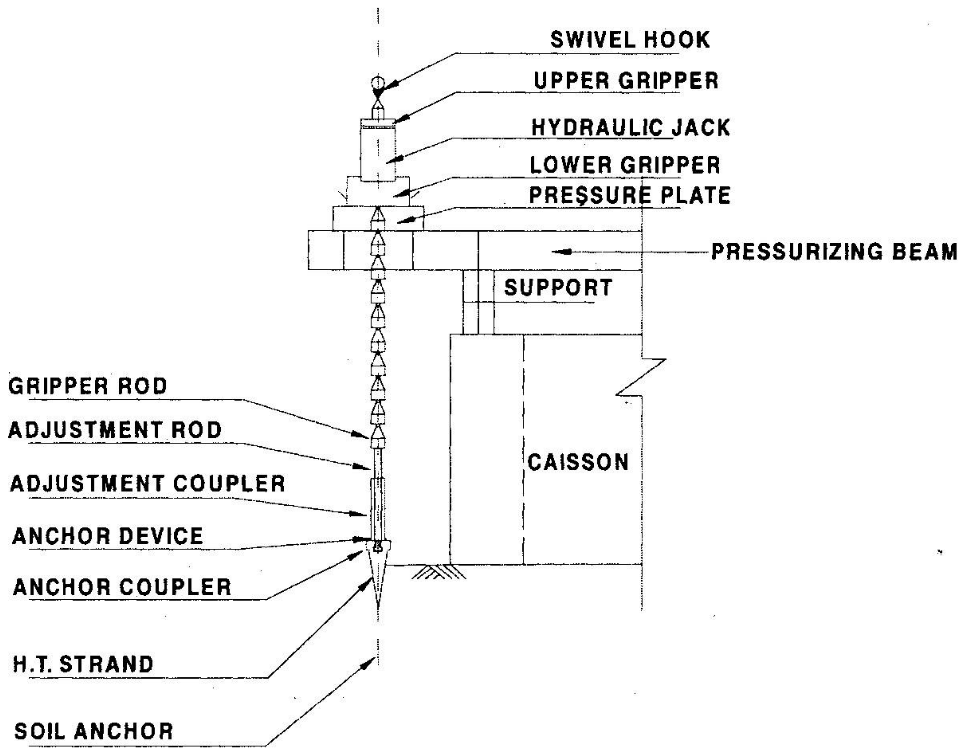
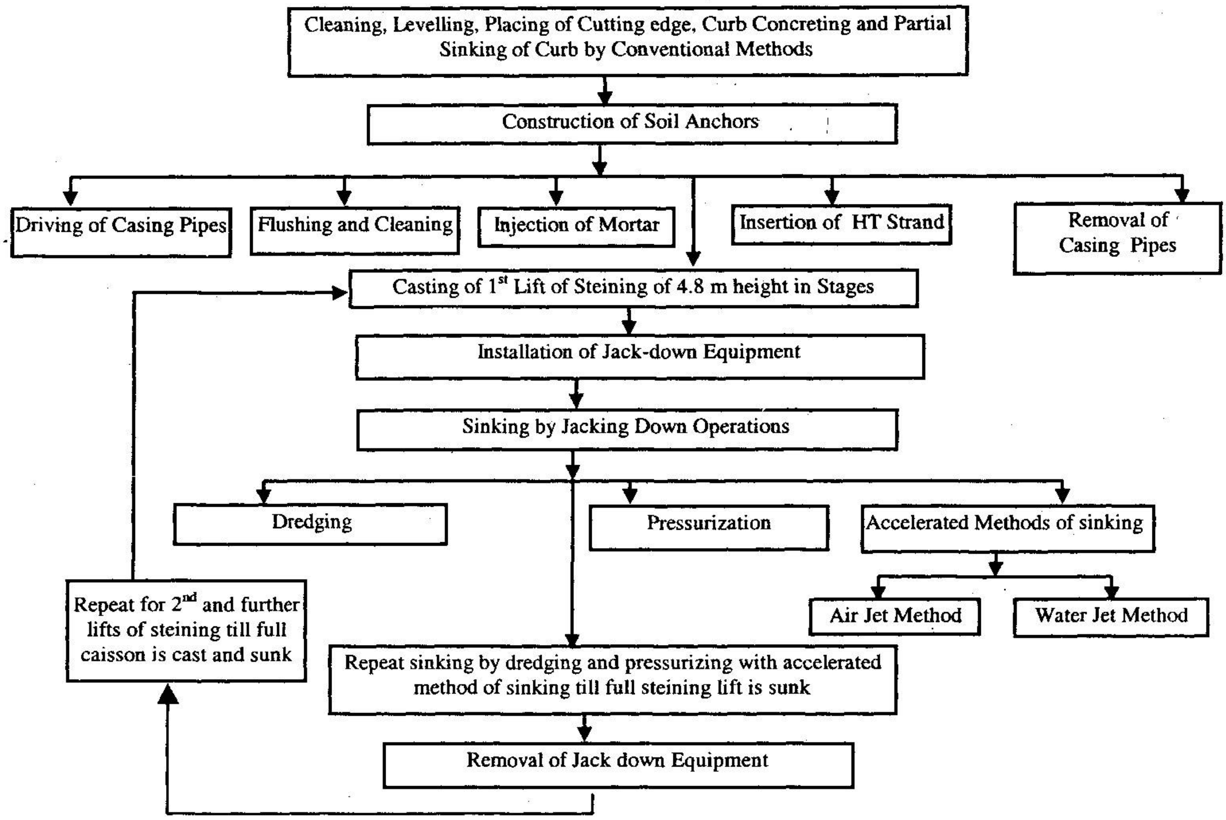


Fig.5. Components of jack down method

The sinking of 4.8 m lift of steining by Jack-down method for oval D-shaped caisson of 15.1 m x 7.10 m size has taken about 8 days, with an average rate of sinking of the order of 60 to 70 cm/day.

A typical flow chart of activities involved in construction and sinking of caisson by Jack-down method is illustrated in the following chart.

Flow chart for construction of caisson by Jack-down method



4. SAVING IN TIME AND COST BY ADOPTING JACK DOWN METHOD

Nizamudding bridge which was started in Feb. 1996 and was scheduled to be completed by March 1998, was completed in Feb. 1998 itself. Thus time and cost overruns which are generally experienced in most of the construction projects in our country were avoided. Early completion of the project was due to mechanization of site activities, specially the well sinking by jack down method. The sinking of 15.1 m x 7.1 m size oval shaped caisson within permissible limits of tilts and shifts by conventional methods of sinking is a very difficult and time consuming process. Therefore, it is the normal practice to adopt two circular wells of 6 to 8 m dia in place of single double D well of large size. The normal construction time of two single circular wells of 6 to 8 m ø dia upto well cap level with 36 m depth below LWL by normal method is about 240 days, while this large oval shaped caisson was completed in 130 to 135 days. Thus, the time required for completion of foundations of Nizamuddin Bridge by Jack down method was considerably less than that required by conventional method. For sinking of wells by conventional methods, the thickness of steining should be sufficient to sink the well under its own weight with little kentledge. By adopting jack down method, thickness of steining can be reduced as per actual design requirements due to its controlled operations. On Nizamuddin Bridge, RCC steining of 125 cm thickness has been provided while as per codal requirements, minimum thickness works out to 175 cm. Therefore, there was also substantial saving in concrete in well steining by adopting Jack down method.

5. CONCLUSIONS

The special method of sinking adopted on Nizamuddin bridge is one of the important factors for fast construction of the project. Fast construction and sinking of oval D-shaped 15.1 m x 7.10 m size caissons with permissible tilts and shifts could be possible only by Jack-down method of sinking supported by air and water jetting. The following conclusions can be drawn from the execution of this project:

- Jack-down method is simple mechanization of sinking process and can be adopted on projects specially with higher depths of foundations and large size of caisson in all types of strata.

- With mechanized system and controlled operations of sinking, speed of construction and tilts and shifts of caisson are effectively controlled which are the two major factors in construction of caisson foundations.
- Provisions in Indian codes for steining thickness are mainly based on the assumption that thickness of steining should be sufficient for self sinking of caisson to reduce sinking efforts and to avoid excessive loading during sinking. Therefore, considerable saving in concrete and thereby in cost can be made by reducing thickness of steining with Jack-down method of sinking.
- The faster completion of the project due to fast progress of sinking and construction of foundation shall considerably affect the benefit-cost ratio.
- Economics of Jack-down method is of course a point for study but it is only the initial investment in procurement of Jack-down equipment while the operational cost is very nominal. Though the soil anchors are non-recoverable, even then overall impact on the total cost of the project by adopting these mechanized methods after economizing the designs and with faster speed of construction shall be very nominal.
- Jack-down method is more effective in controlling the tilts and shifts in sinking of caissons and could be tried on important projects.
- Air jet method as adopted on this project is also a systematic and effective approach for reducing the soil friction around the caisson. This method can be used on all sites without any difficulty and with a little cost and efforts as it does not involve any special measures.

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