RESEARCH AND APPLICATION OF BRIDGE BEAM RAISING TECHNOLOGY BY FORCE RESISTANCE STEEL PIPES TO REPLACE BEARING IN NORMAL TRAFFIC CONDITIONS

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1 – INTRODUCTION

The Vietnamese Transport sector is using a large number of old bridges majority of which are reinforced-concrete bridges built after 1930. Besides the annual maintenance, old bridge bearing are replaced by steel and rubber ones. Bearing replacement is not technically complicated but it is a difficult and even impossible job because suitable technology is needed to ensure normal traffic operation during the implementation period. Deteriorated bearing leads to obligatory deformations, beam creaking and other local failures.

In order to meet the practical demands, in 1999 the Transport Ministry assigned the Research Institute for Transportation Science and Technology to carry out a research project . “Study on Rubber Bearing Replacement Technology for simple Beam Bridge in Viet Nam using Rubber Bearing". After the subject had been examined, the Vietnamese Road Administration allowed us to apply experimentally on two bridges : Phu bridge on National Highway 1A with the span length of 24m and span weight of 35 tons, and Ghep bridge with the span length of 33m and span weight of 60 tons. The successful experimentally results on the two bridges have offered bright prospect of effective application of beam raising technology for bearing replacement in the field of bridge maintenance, especially for deteriorated bridges in Viet Nam

Figure 1 : Beam raising execution in Ghep bridge
(National Highway 1A – Thanh Hoa province)

2. SELECTION OF BRIDGE BEARING REPLACEMENT TECHNOLOGY

2.1 OPERATIONAL PRINCIPLE OF THE TECHNOLOGICAL STRUCTURE.

Normally, when a bridge is in operation, the whole span becomes a working structural system in an internal hyper-static space. To comply with the operational principle and keeping traffic in normal traffic, there must not be any local obligatory deformation in any structural part. Thus, for bearing replacement, one end of the span or the whole span must be raised to the same elevation so as to avoid causing any deformation, or if any, it must be within acceptable limit.

2.2. SOME TRADITIONAL TECHNOLOGICAL SOLUTIONS.

2.2.1. THE APPLICATION OF LEVERAGE PRINCIPLE.

Lever system is formed by rigid steel girders acting as lever arms placed on symmetrical beams of the two spans over the support's neutral axes. To have high rigidity, the lever arms are strengthened by strengthening edges and one end of the lever arm is rigidly attached to the beam by means of connecting anchor. When one end of the lever arm is jacked, one end of the asymmetrical beam is simultaneously raised; therefore, the old bearing can be replaced. The following principle for beam rising must be obeyed: The number of jacks is equal to the number of beams and all the beams of a span must be raised simultaneously at the same time.

The major advantages of this technological solution are stated as follows. The simple equipment system is suitable for the technological ability of local maintenance management units. However, the disadvantage of this technology can be seen from the figure. That is all traffic means are not allowed to cross the bridge during process of bridge bearing replacement. This causes a lot of problems affecting directly traffic operation, especially on major important national highways.

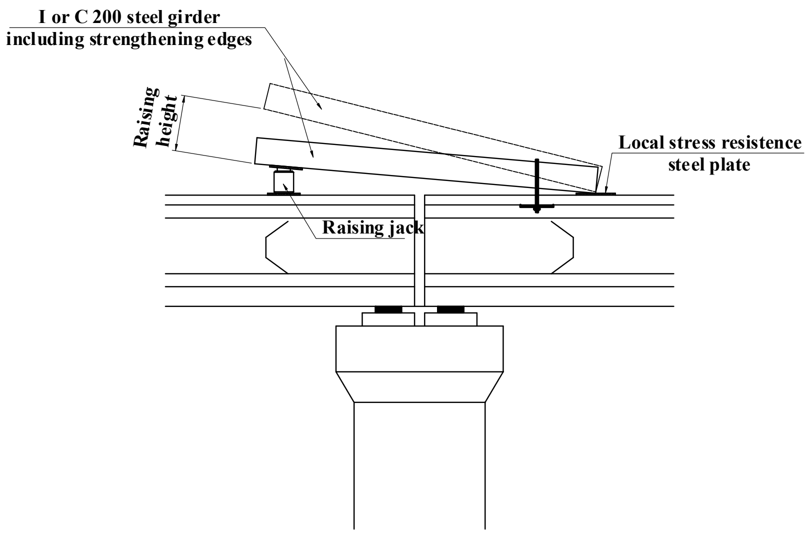

Figure 2 : The application of lever principle

2.2.2. TOP FLANGE RAISING SOLUTION

The structural principle of the technology is presented in figure 2. The diagram of this technology can be summarized as follows: All the jacks are placed on the top of the cross head, in the gap between two adjacent beams. To transmit the jacked force to the beam, the flange supporting structure is formed by U or I and plate steel girders with strengthening flanks. The beam raising procedure is the same as of the first solution.

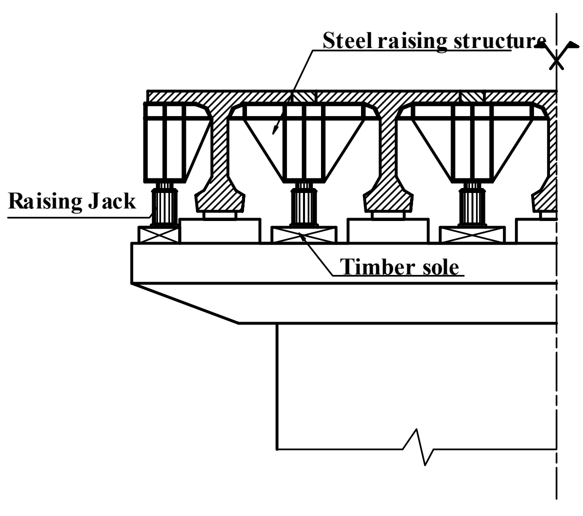

Figure 3 : The top flange raising solution

The top flange raising solution above is quite suitable for small bridges. This solution has the following advantages: The maximum load bearing capacity of the support is used for transferring raising force, material cost is low, the period of implementation is reduced, clearance under the bridge is ensured for navigation. However, the major disadvantage of this solution is that the stabilization and safety requirements can not maximally met, especially for long-spanned bridges.

2.2.3. FLAT JACK SOLUTION

Flat jack solution is considered to be an advanced technology now. The structural principle of the technology can be summarized as follows: Flat jacks are produced in the form of plates with the typical diameter of 30 cm and the thickness of 3 cm. The jack's beam raising capacity is 50 - 70 tons. The jack operates on the systematic principle. Each system consisting of 5 - 10 jacks shares the same hydraulic oil pump. The jacks operate under the following principle: Under hydraulic pressure, the two surfaces of the jack will be swelled to create the jack's stroke; therefore, the magnitude of the stroke is usually 1-2 cm.

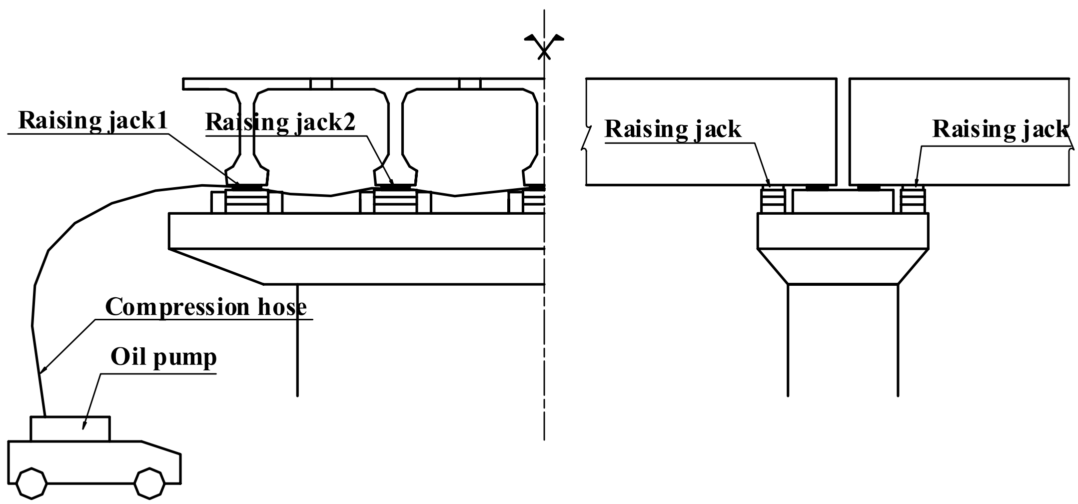

Figure 4 : Flat jack solution

To raise the bridge beams, the jacks are placed in the open zone just in-front of the old bearing in a way that the jacks lay on the central line of the bridge beam. Setting jacks in this position doesn't lead to negative effects produced by local force appearing during beam raising process. Generally, compared to other traditional solutions, the flat jack solution shows many advantages. These advantages are: neat and light specialized equipment, simple operation and maintaining normal traffic condition during bridge beam raising process. However, this solution is just suitable for small bridges built with large bearing shelf. especially when the bearing center is far from the support surface so that there is enough space for jack placement and the jack operation can not destroy locally the pier's structure. Thus, precise calculations should be done so that the suitable position for jack placement can be identified. Because of these typical characteristics, flat jack solution is applied in many bridges built with short spans (≤ 24,7m) and large bearing shelf, satisfying the requirements of this technology. On the other hand, bridges in the north, particularly on important highways, this solution (technology) doesn't work because the old bearing was placed too near the support edge and in many cases, the flat jack center lies outside the support surface. The surveys on Phu bridge (in Ha Tinh);

Ghep bridge (in Thanh Hoa) and Gian Khau bridge (in Ninh Binh), all of them are on the national highway $N^0$1, indicate that most of the bearings are very close to the support edge. That is why, flat jack solution is impossible to apply.

2.3 – BRIDGE BEAM RAISING SOLUTIONS BY FORCE RESISTANCE STEEL PIPES.

The beam raising solution by force resistance steel pipes is the most advanced solution now. The equipment system comprises main parts: The system of raising jack groups and main oil pump, the system of force resistance steel pipes and other related parts.

a – Technical parameters.

The technical parameters of equipment system were calculated based on considering the directly effective factors. When estimating the raising capacity of jack, we assumed that the load combination included: The self-weigh of beams and acting loads of vehicle fleet crossing the bridge. The diameter and thickness of steel pipes are identified from calculating the reaction of jack. The results shown:

- For moderate short reinforced concrete bridge spans (≤24m), the equipment system has following parameters :
  + Raising capacity of jack: 50 – 70 T/ jack
  + Max stroke of jack: 5 cm
  + The diameter of steel pipes: Φ = 130 mm (outside diameter)
  + The thickness of steel pipes: δ = 12-15 mm.
- For long reinforced concrete bridge spans (30 – 40 m)
  + Raising capacity of jack: 100 T/ jack
  + Max stroke of jack: 5 cm
  + The diameter of steel pipes: Φ = 245 mm (outside diameter)
  + The thickness of steel pipes: δ = 22.5 mm.

b – The technological structure.

The system of steel pipes structure and jacks are formed in groups. Each group include a number of steel pipes, jacks and a main hydraulic pump. The number of steel pipes is equal to the number of beams of the bridge span. The steel pipes are set on bridge bearing shelf. If the cross head surface is not large enough space to arrange the steel pipes we need to extend it by steel structure.

Steel pipe soles are set on top of steel pipes. The jack soles must cover the top surface of steel pipes. The raising jacks are set on the soles. Vertical axis of the jacks must be coincided with the central line of the beam bottom following the structural principle represented above, when the main hydraulic pump acts, all the raising jacks in a groups also operate simultaneously. One jack group is replaced at the bridge abutment but two groups are placed on the pier so that both symmetrical ends of the span are raised at the same time and there would not be difference in bridge surface elevation at expansion join positions. This also ensures relative smooth traffic movement over the bridge.

Generally, the technological operation process is carried out starting from bridge abutment to individual bridge piers and then to final abutment. In order to create high stability and convenient assembly, the steel pipe structure is strengthened by transverse strengthening system. Before setting the steel pipes on the pier, the steel pipes should be measured and adjusted so that it stands vertically. The steel pipes are produced in modules with the lengths ranging from 20 cm, 50 cm, 100 cm and 200 cm. The length of steel pipes is identified based on the bridge support height. The modules are connected by connecting bolt. When the bridge pier is too high, steel pipes resting on normal base don't ensure stability because the pipes have great free compression resistance length. We, therefore, can place the jacks on steel structure. This jack supporting structure is formed by straight and triangular steel girders... The steel pier bracket is linked to the pier by pre-stressed bars.

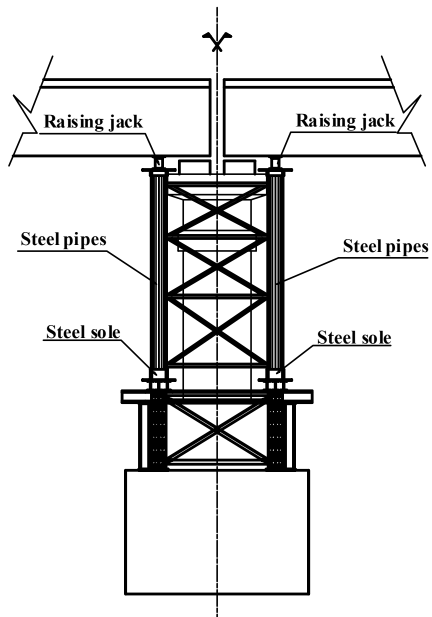

Figure 5 : Bridge beam raising solutions by force resistance steel pipes.

The number of pre-stressed bars is identified by considering the magnitude of the jack's direct raising force and the self-weight of steel pier bracket. The fig 8 describes the working model of steel pier bracket structure.

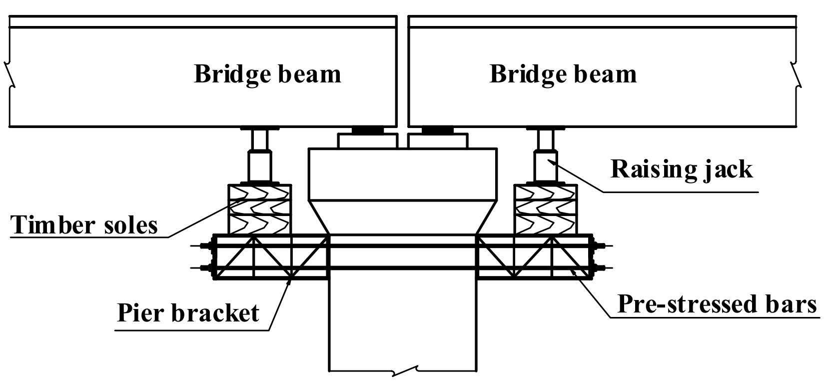

Figure 6 : Bridge beam raising solutions by solution of jacks set on pier bracket

In calculating we need to solve 2 main matters: friction through surface compression and upturning resistance. To keep contact between the steel pier bracket and surface of bridge support, the reaction V must satisfies the condition:

$$V = R \cdot f > G + P \quad (1)$$

Of which: R _ Total of pre-stressed force of bars

f _ frictional coefficient between steel and concrete.

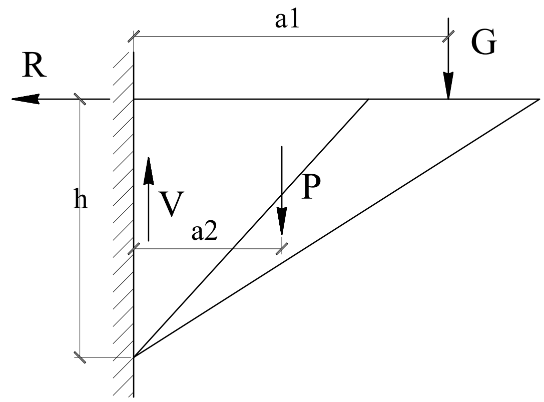

Figure 7 : Structural model pier bracket

To keep upturning resistance, reaction force V must be strengthened with condition:

$$M_R > M_{G+P} \quad (2)$$

From fig 8, the reaction R is identified basing on assumption of the equal moment at B as :

$$R \cdot h - G \cdot a_1 - P \cdot a_2 = 0$$

$$R = \frac{G.a_1 + P.a_2}{h} \quad (3)$$

From (3) we can calculate the number n of high strength bar.

$$n = \frac{R}{F.\sigma_n}$$

of which : F_t : cross section area of the high strength bar

σ_n : Pull resistance capacity of the high strength bar.

3 – APPLICATION RESULTS.

In the years 2000 and 2002 The Research Institute for Transportation Science and Technology was assigned the missions of replacing all the deteriorated rubber bearing of Phu and Ghep bridges on National Highway 1A in Ha Tinh and Thanh Hoa province with 9 reinforced concrete bridge spans. To carry out the projects, the Science and Technology Centre for Transport Means and Construction Protection manufactured 90 steel plates reinforced – Neopren rubber bearings according 22TCN 217-94 standard the jack system for bridge beam raising with parameter presented in item 2.3. From the experience gained in Phu bridge and Ghep bridge, the technological equipment system has been improved a lot to overcome the disadvantage of the old equipment system such as : Each jack group works in a synchronous mechanism through a main hydraulic pump (In Phu bridge the jacks work independently). Brake valve is added to the jack and it is able to keep the bridge structure safe when there are vehicles running out it (In Phu bridge we had tot use safety wedges). With improved technical parameters, following advantages and experience have been created: such as : The technological manipulations is much simple because jacks operate under the same pressure and there are not significant difference of height level of beams, thus this can satisfy maximally the safety requirements. Also, the safety brake valves allow vehicles to cross the bridge normally during the execution time and 12 hours before taking the bridge beams down to the designed position on Sikadure layer creating longitudinal and transverse slope executed before. Practically, the technological solution applied in Ghep Bridge has given real economical and social effects. The economical effects is expressed in term of short execution time such as 40 days for replacing 30 bearings in Phu brigde, 60 days for 60 bearings in Ghep bridge. The advanced operational mechanism and equipment are suitable for construction characteristics and we don't need to divide the extra traffic routes or construct the side-track that cost a lot of money. Besides, this technological solution allows normal execution and doesn't bring about traffic jams on river and on highways. This solution is really great of socio-economic one.

4 – REFERENCES

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