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Study of Parameters Which Affect the Strength of Concrete by External Prestressing

Prof. Yogesh Ravindra Suryawanshi[1], Ms. Manisha Bhise[2]
[1,(]*Department of Civil Engineering,Dr DYPSOE Pune, University of Pune, Pune, India)*
[2,(]*ME- Struct Student, Department of Civil Engineering,Dr DYPSOE Pune, University of Pune, Pune, India)*

Abstract: *- The normal interaction between steel and concrete is lost because the tendons are unbonded with the concrete cross section. Therefore the assumption of plane sections is no longer valid. External pre-stressing has been proven cost effective and technically attractive worldwide, as it leads to substantial cost savings and a large decrease in construction time. If the purpose of the project is to improve the load carrying capacity of existing bridges, then tendons are usually, placed outside the bridge girders, tensioned and anchored at their ends. The external tendons can be made of steel, but also with fibre reinforced polymeric (FRP) materials and they provide one of the most efficient solutions to increase the rating capacity of existing bridges when the infrastructures are in need of renewal and made of all structural materials, such as concrete, steel and timber.*
There are some different techniques to strengthen existing structures such as plate bonding, external pre-stressing, over-slabbing or increasing the ratio of bonded reinforcement. Recent works on structural repair procedures have shown that reinforced concrete beams can retain as much as 85% of their flexural capacity. While there are similarities between external pre-stressing and external reinforcement, the structural principles in which the two methods work are different. In present paper work, we are made only study different researchers works on different parameters which are affected on externally prestressing. We were collected the information on external prestressing from different research papers and made discussion on parameters which are affected on it.

1. INTRODUCTION

There are some different techniques to strengthen existing structures such as plate bonding, external pre-stressing, over-slabbing or increasing the ratio of bonded reinforcement. Recent works on structural repair procedures have shown that reinforced concrete beams can retain as much as 85% of their flexural capacity. While there are similarities between external pre-stressing and external reinforcement, the structural principles in which the two methods work are different. The external reinforcement is indirectly stressed by the deformation of the structure, and it turns the structural behaviour in a hybrid of flexural and tied arch action. The external pre-stressing actively inducts load by tendons to impose stress to the concrete, and the behaviour remains predominantly flexural. During a flexural analysis, or from a design viewpoint, external tendons can be treated as unbounded tendons provided secondary effects and frictional forces at deviators are neglected. The analysis of beams with unbonded tendons, pre stressed or partially pre-stressed, has one additional level of difficulty in comparison to the analysis of beams with bonded tendons, in fact, the stress in tendons raises up beyond the effective pre-stress due to external loading is member-dependent instead of being section-dependent. Besides, the stress in unbonded tendons depends on the deformation of the whole member and is assumed uniform in all the sections; it cannot be found with the cross section's analysis, as for bonded tendons. The stress increase in the tendons, namely *fps*, must be determined from the analysis of deformations of the entire structure, both for the elastic state and ultimate state. The normal interaction between steel and concrete is lost because the tendons are unbonded with the concrete cross section. Therefore the assumption of plane sections is no longer valid.External pre-stressing has been proven cost effective and technically attractive worldwide, as it leads to substantial cost savings and a large decrease in construction time. If the purpose of the project is to improve the load carrying capacity of existing bridges, then tendons are usually, placed outside the bridge girders, tensioned and anchored at their ends. The external tendons can be made of steel, but also with fibre reinforced polymeric (FRP) materials, and they provide one of the most efficient solutions to increase the rating capacity of existing bridges when the infrastructures are in need of renewal and made of all structural materials, such as concrete, steel and timber.

1.1 Application Of Prestressing

[1] In structural Member, where the span length is very high with low rises and low structural height, the application of Reinforced Cement Concrete shall be virtually impractical. In such a case, Prestressing is used to achieve a light weight, elegant looking and much economical structure with high durability. Prestressing, therefore, is widely used for long span beams and Bridges.

[2] In building structure also, prestressing method is very effectively used to achieve lighter beams and slabs; thus reducing their dead load considerably as compared to R.C.C. Structures. Application of Prestressing in building construction also facilitates a larger span between the columns, thus reduces the number of columns. This also makes the structure more versatile for interior planning.

[3] Prestressing is also very widely used in the construction of Mega Structures like Containment Wall of Nuclear Reactors, LNG Storage Tanks, Cement Silos, Chimneys, Dams and Rock Anchors etc.

1.2 Scope Study

[1] To study parameters affecting the strength of prestressed concrete bridge.

[2] Alternative solution for increase strength of prestressed concrete bridge.

II. SYSTEM OF PRESTRESSING

2.1 System of Prestressing:

Prestressing is a method of inducing known permanent stresses in a structure or member before the full or live load is applied. These stresses are induced by tensioning the High Tensile Strands, wires or rods, and then anchored to the member being Prestressed, by mechanical means.The Prestressing counteracts the stresses, produced by subsequent loading on thestructures, thereby extending the range of stresses to which a structural member can safely be subjected. This also improves the behaviour of the material of which the member or structure is composed. For Example; The Concrete which has relatively a low Tensile strength, shall behave like a member having high tensile strength, after Prestressing. The High Tensile wires/strands, when bunched together are called Cables. These cables are generally placed inside a cylindrical duct made out of either metallic or HDPE material. The Anchorages, one of the main components of the Prestressing activity, are used to anchor the H.T. Cable after inducing the Load. The whole assembly of the Anchorage and the H.T. Cable is named as 'TENDON'.

2.2 Methods Of Prestressing Systems

Prestressing System can be classified by two basic methods, as under:-

2.2.1 External Prestressing

When the prestressing is achieved by elements located outside the concrete, it is called external prestressing. The tendons can lie outside the member (for example in I-girders or walls) or inside the hollow space of a box girder. This technique is adopted in bridges and strengthening of buildings. In the following figure, the box girder of a bridge is prestressed with tendons that lie outside the concrete.

Fig.2.1 External prestressing of a box girder (Reference:VSL International Ltd.)

2.2.2 Internal Prestressing

When the prestressing is achieved by elements located inside the concrete member (commonly, by embedded tendons), it is called internal prestressing. Most of the applications of prestressing are internal prestressing. In the following figure, concrete will be cast around the ducts for placing the tendons.

Fig.2.2.internal prestressing of a box girder (courtesy: cochin trust ,kerala)

2.2.3 Pre-Tensioning - is a method where Prestressing Steels are pre-stressed, prior to concreting, against two rigid abutments. This method is most widely used for mass production of short span structures, where pre-stressing is also a prerequisite, such as; Railway Sleepers, Electric Polls, Fencing Polls, Pre-Tensioned Slabs and **I-**Section Bridge Girders etc.In this system, a number of identical structural frames are placed in between thetwo rigid abutments or reaction bolster. Prestressing Steel is then placed longitudinally across these frames and abutments, in the required orientation, and stressed. After achieving required elongation and stresses they are blocked at two abutments and then concrete is poured in the frames with stressed steels in position.

2.2.4Post-Tensioning–itis a method where Prestressing Steels are stressed after concrete attains its preliminary strength. Two extreme ends of the structure are considered as a reaction face, against which force is applied. Ducts are placed inside the formwork alongwith reinforcement and the concreting is completed. After achieving required concrete strength, a stipulated numbers of Prestressing Steel is then inserted in each duct for stressing purpose. After achieving required elongation and stresses they are blocked at two ends with the help of Anchor Plates and grip.

2.3 The Components Prestressing

2.3.1Forms of Prestressing Steel

a. Tendon **-** A stretched element used in a concrete member to impart prestress to the concrete
b. Wires **-** Prestressing wire is a single unit made of steel.
c. Strands **-** Two, three or seven wires are wound to form a prestressing strand.
d. Cable **-** A group of strands form a prestressing cable.
e. Bars **-** A tendon can be made up of a single steel bar. The diameter of a bar is much larger than the of a wire

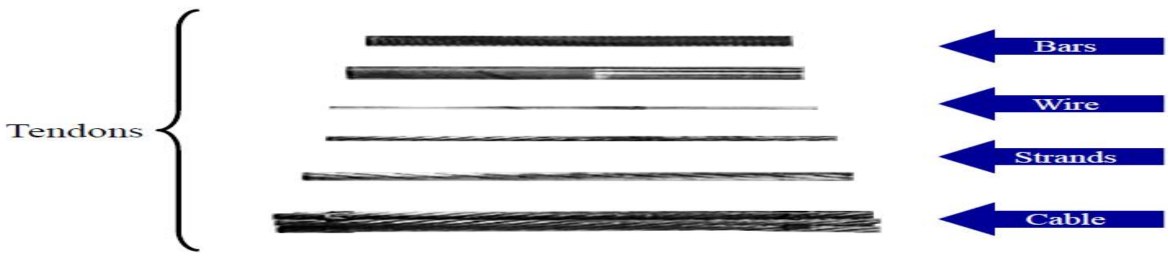

Fig .2.3.Forms of Prestressing Steel

2.3.2Anchorages

Prestressing forces of the Tendons are transferred to the concrete structures through Anchorages. Anchorage for the Post Tensioning system normally comprises of a steel plates with a number of conical holes, the conical Grips and the Guide (Trumpet). Trumpet or Guide is used to connect the ducts and provides a flat surface for locating the Bearing Plate on it. As shown in the figure below:

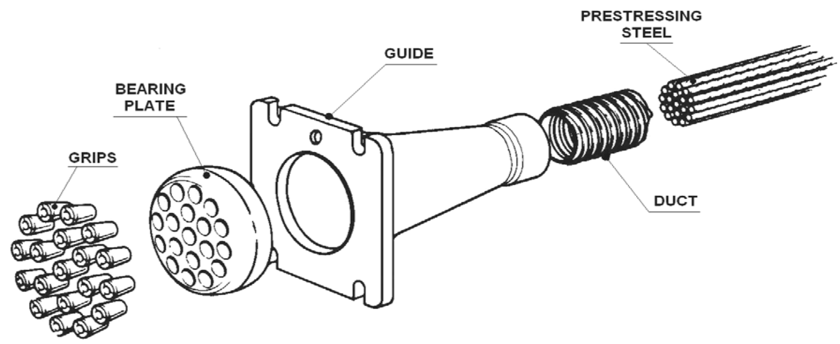

Fig.2.4. Anchorages

2.3.3Tendon Ducts (Sheathing)

Sheathing is used to create a void in the concrete structure, through which the stressing steels are inserted and remain free to stretch during stressing operation.

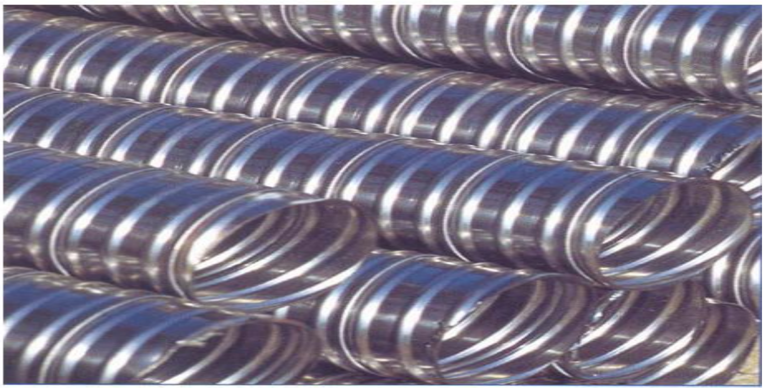

Fig.2.5. Tendon Ducts (Sheathing)

2.3.3Tendon Supports

To ensure the adequate transfer of calculated forces to the structure, it is very important that the tendon profile and the location of the duct, in 'X' & 'Y' directions are maintained as shown in the drawing. For this purpose; the ducts needs to be properly supported and secured at an intervals of 0.50 – 0.70 meter. The axis of the duct is considered as the line of Center of Gravity of the tendon.

III. METHODS OF PRESTRESSING

3.1 Factors affecting on strength ofprestressed concrete bridge

3.1 Layout of tendon

According to Oliver Burdet et all (2000),the parallel design of a typical box girder highway bridge with internal and external tendons has shown that the differences between the two solutions are smaller than anticipated. More efficient cable used for external prestressing.The layout of cable was used trapezoidal which is more efficient than the usually adopted parabolic layout.According to Amer M. Ibrahim, (2010),The beams with a draped tendon profile showed a higher ultimate load and a stiffer response compared to beams with a straight tendon profile. This is attributed to the fact that failure occurs where the effective depth of the tendon is largest.

3.2 Methods of Prestressing

According to Boudex (2000),The comparative study was conducted to quantify the influence of the type of prestressing (internal or external) used in the design of a concrete box-girder highway bridge. For the girder configuration and under the simplifying assumptions used in this study, the following applies: The difference in the amount of prestressing between comparable internal and externally prestressed girders depends on the girder height. For example, external prestressing requires approximately 20 % more prestressing force for a girder height of 2.2 m. At girder heights above 3.5 m however, internal prestressing becomes the more favourable type of prestressing. Unlike internally prestressed girders, the ultimate flexural capacity of externally prestressed girders provided by the passive and prestressed reinforcement designed on the basis of commonly used serviceability criteria for bridges (deflection and crack control) tends to be insufficient for structural safety.

The required web shear reinforcement at the support is 10 % to 15 % higher in the case of external prestressing.According to Nihal D Ayawardena et all,(2002) it is structurally advantageous to combine pretensioned concrete members,having internally bonded tendons,with externally post-tensioned tendons.futurestrengthing of concrete members can be more easily accomplished by external prestressing.placement or addition of new tendons can be easily accommodated.In external post-tensioned tendons can be easily inspected in the event corrosion occurs.it was propsed that web thikness of Nabska be reduced by 76mm.Thus reducing the self weight. According to HeroshiMutsuyoshi (2008) in all the new technologies external prestressing is used. In Japan ,a number of innovative technologies have been developed to increase not only the structural performance but also the long term duryability of prestressed concrete bridge.
According to Oliver Burdet et all (2000),the parallel design of a typical box girder highway bridge with internal and external tendons has shown that the differences between the two solutions are smaller than anticipated.For small spans,or more appropriately for shallow cross sections (less than 3m),the solution with internal tendons leads to a smaller amount of reinforcement ,both passive and prestressed . For deeper cross sections,the solution with external tendons requires less reinforcement.

3.3 Effective Depth of External Prestressing Tendon

According to Amer M. Ibrahim, (2010) a result of increased effective depth of externally prestressed tendon, the cracking load, post cracking stiffness and ultimate load capacity are essentially increased. This increase is very clear in a beam without deviators at the mid-span and a straight tendon profile (B10S1B) and greater than that for a beam with deviated tendon (B6D1) at the midspan. This means that deviators reduce the second – order effects and the change in eccentricity of the tendon. This may be attributed to the increase in eccentricity of the tendon which causes an increase in its distance from the neutral axis; the greater the distance the higher the stress.

3.4 Eccentricity

According to Hiroshi Mutsuyoshi (2008) ,Although externally prestressed PC bridges are well recognized to have several advantages, however, they have lower flexural strength compared to that of bridges with internally bonded tendons. This is due to the smaller tendon eccentricity, which is limited by the bounds of concrete section of girder (i.e., at the bottom slab in case of box-girder bridges as well as the reduction in tendon eccentricity at the ultimate flexural failure.

3.5 Materials of Tendons

According to Huang Jian1 (2007) carbon fibre reinforced polymer (CFRP) material has properties of high strength, non-corrosion, light-weight and low relaxation amongst others. Because of its brittleness, lack of ductility and high cost, up to now it has been used in only very few bridges instead of in the world. Owing to the development of CFRP material, the researchers are confident that CFRP tendons will be used in P.C. bridges in China. Hewei Bridge is the first example of a highway bridge using CFRP prestressing tendons. Carbon Fibre Composite Cable (CFCC) which is formed by twisting a number of small-diameter CFRP rods similar to conventional steel strands. Comparing the two types of CFRP tendons, the work efficiency of CFCC tendons is higher than that of CFRP rods in external prestressed bridge girders. CFCC cables can be easily laid out in a draped tendon profile according to the variation of bending moment along the length of girder. But for CFRP rods, only multi-rod anchors and straight tendon profiles can be used in order to obtain a smaller eccentricity of the tendon. The mechanical properties of pre-stressing steel are not so susceptible to variations in temperature. The lifetime of the steel could be shorter in pre-stressed concrete, because of that steel is stressed up to 50-60% of its ultimate strength. A fatigue life of 2 million cycles is considered sufficient in the main part of the applications. The pre-stressing steel is much more sensible to corrosion than the reinforcing one. The exposion of unprotected steels to the environments, even for a few months, can produce a large reduction of mechanical properties but also in the fatigue life. FRP tendons are constituted by thousands of small fibers that are embedded in a polymermatrix.The strength of an FRP tendon depends on the production process. The stress-strain curves arelinear up to failure without a plastic redistribution of stresses. In FRP reinforcements are long term static stresses that can lead to a decrease in tensile strength. FRP fibers have an excellent resistance to creep, but the same quality is not common to all resin systems. The FRP mechanical properties dependence on temperature is given by the resin matrix. For structural uses, the glass transition temperature, that is the point in which the resin or the fiber goes from solid to a viscous liquid, has to be above the maximum service temperature. Experimental tests and research have showed that FRP elements have a good-to-excellent fatigue resistance.

IV. DISCUSSION & CONCLUSION

From study of all reference paper following discussion and conclusion has get:

a. Externally prestressed PC bridges are well recognized to have several advantages; however, they have lower flexural strength compared to that of bridges with internally bonded tendons. This is due to the smaller tendon eccentricity, which is limited by the bounds of concrete section of girder (i.e., at the bottom slab in case of box-girder bridges as well as the reduction in tendon eccentricity at the ultimate flexural failure.

b. The difference in the amount of prestressing between comparable internal and externally prestressed girders depends on the girder height. For example, external prestressing requires approximately 20 % more prestressing force for a girder height of 2.2 m. At girder heights above 3.5 m however, internal prestressing becomes the mor favorable type of prestressing.

c. FRP can used to increase flexturer strength and shear strength .

d. The innovated technologies can be used. It consits light of new structural systems, external prestressing with highly eccentric tendons and extradosed prestressing are excellent examples of a wider use of external prestressing technology to achieve a PC bridge with improved structural performance as well as cost-effective outlook

REFERENCES

Journal Papers:

[1] King Hwee& Robert A.Tajendra., "Strengthening of precast concrete girder bridges by post tensioning for continuity"*PCI Journal ,2003,vol.2.p.p 10-15*.

[2] Amer M. Ibrahim ., "Parametric Study of Continuous Concrete Beam Prestressed with External Tendon Jordan"*Journal of Civil Engineering, Volume 4, No. 3, 2010.*

[3] Nihal Don Ariyawarddena And Admin Gali., "Design Of Precast Prestressed Concrete Member Using External Prestressing"*PCI Journal ,2002,vol.5.p.p 84-94.*

Conferences Papers:

[4] Olivier Burdet& Mark Bodoux.,"Comparison of internal and external Prestressing for typical highway bridge"*16th conference of "IABSE"Lucrane 2000.*

[5] Huang Jian1 & Xia Wengjun**.,"**Use of external cfrp prestressing in hewei bridge in china"*Proceedings of the 26th Southern African Transport Conference (SATC 2007).*

[6] Hroshimutsuyoshi., "Prestrssed Concrete Bridges In Japan : Technological Advancements And Future Prospects"*the 3rd ACF international conference-ACF/VCA 2008.*