Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 7 (1964)

Artikel: Development of a jointing technique for precast columns

Autor: Spyra, J.J. / Smith, R.B.L.

DOI: https://doi.org/10.5169/seals-7982

IVb4

Development of a Jointing Technique for Precast Columns

Le développement d'une technique d'assemblage des piliers préfabriqués

Die Entwicklung eines Verbindungssystems für vorgefertigte Pfeiler

J. J. SPYRA
Consulting Engineer, Manchester and London

R. B. L. SMITH
Ph. D., Lecturer, Manchester College of Science and Technology

This paper describes the development of a type of joint for precast columns. The idea is shown in Fig. 3. The reinforcement of the lower part terminates in steel tubes welded to the column rods, and projecting rods from the bottom of the upper part are inserted into the tubes and the joint is made by an expanding cement grout which has been placed in the tube. The excess grout combines with the normal jointing grout between the concrete contact areas and is prevented from spilling down exposed faces by the edge seals shown. No grout holes are required and the joint can be made by unskilled labour. Tests have indicated that such joints can achieve the full yield strength of the reinforcement with only about nine rod diameters length of joint.

The first tests compared the strengths of glued joints made with normal Portland cement grout with those of epoxy resin. A deformed reinforcing bar was pulled out of a hole formed by ribbed metal sheathing in a concrete block. The joint was made by pouring a quantity of the "glue" into the hole, inserting the rod and curing for seven days. The result of these tests may be summarised as follows: at a load corresponding to about one half of the permitted design tensile stress of the rod, the rod was pulled out of the joints using cement grout, but in the case of the epoxy resin joints the concrete blocks split, at a somewhat higher load, without any damage to the joints.

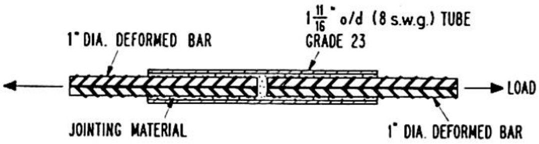

Fig. 1.

Consequently it was decided to design further tests on the basis of direct transfer of tension along the reinforcement through the joints, and this led to results, using epoxy resin joints, in close agreement with the work of IGONIN [1]. A test specimen is shown in Fig. 1. The size of the tube was chosen to have an easy fit for the bar and to have approximately the same cross-sectional area as the bar. Using epoxy resin (Araldite X 83/120, six parts, with hardener MY/750, ten parts[1]) as jointing material, tests at the age of one day with 6 inches grip length of rod resulted in yielding followed by rupture of the tube at the section where the two rods abut.

With this type of test specimen it was difficult to obtain reliable compaction, and therefore in further tests the detail shown in Fig. 2 was used. A rod is welded to one end of the tube and the rod to be jointed is inserted at the other end after the tube has been filled with "glue" in a vertical position.

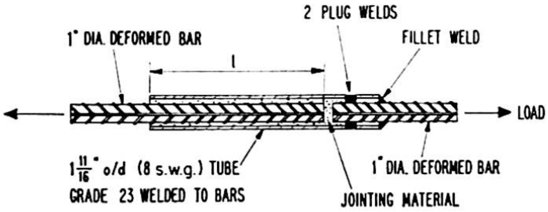

Fig. 2.

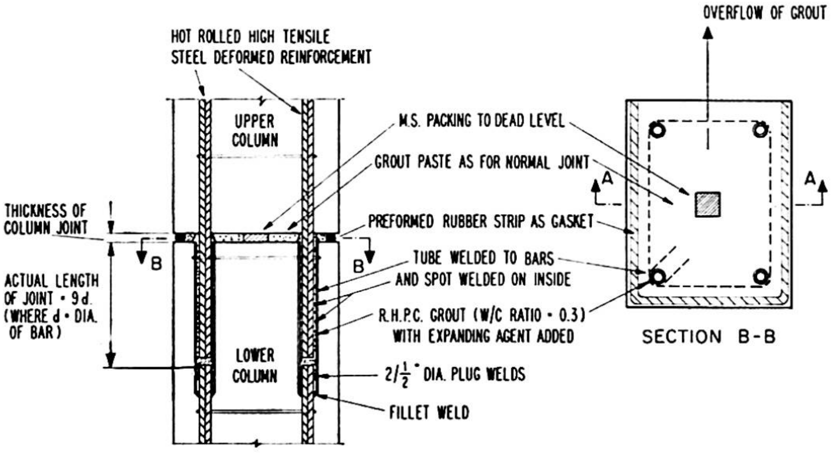

Fig. 3. Typical Column Joint.

This detail corresponds to the actual procedure in construction illustrated in Fig. 3. At this stage of the investigation the fire resistance of these joints was considered, and it had to be accepted that such joints depending on epoxy resin, would not satisfy fire regulations for buildings although they might be quite satisfactory in other types of structure in which the fire risk may be ignored (bridges, silos, roads, etc.). This results from the fact that this material, being organic, is destroyed at 300° C and loses its strength below this temperature, since the first reduction of strength begins at 36° C. So in the final joint design described below, Portland cement grout with an expanding agent and also ciment fondu were used as the jointing material. Methods of providing a mechanical key to the internal wall surface of the tube were investigated.

---

[1]) Manufactured by C.I.B.A. (ARL) Ltd., Duxford, Cambridge, England.

Tests of the Final Design

The first of these tests was carried out using untreated tubes. A marked superiority of load capacity of specimens using Portland cement grout with an expanding agent, Conbex[2]), (Grout PCX) compared with those using ciment fondu without any additives (Grout CF) was discovered. In making these joints, the tube was clamped in a vertical position. A quantity of the grout was fed into it, and gently rodded to eliminate any large voids; the rod to be jointed was then pushed into the tube by a continuous pressure without any vibratory movement. This procedure was strictly applied in order to reproduce the practical conditions in jointing members. For this purpose it was found that the water-cement ratios given in Table 1 were suitable.

Table 1. Failure loads in tons

a) Using untreated tubes. 1″ diameter deformed rods

l, inches		6		9		12	
Type of grout		PCX	CF	PCX	CF	PCX	CF
age at test	3 days	15.0 PO	3.7.PO	18.4 PO	5.0 PO	22.5 WF	5.0 PO
	3 days	—	1.5 PO	—	3.0 PO	—	13.0 PO
	7 days	17.5 PO	—	22.7 WF	—	19.7 WF	—
	8 days	16.0 PO	—	18.4 WF	—	21.5 PO	—

b) Using grooved tubes. All tests, $l = 9$ inches 1″ dia. deformed rods

Type of grout	PCX (1)	PCX (2)	CF (3)	PCX (4)	CF (5)
Age at test	4 days	11 days	4 days	28 days	28 days
Failure load (tons)	14.3 TF	26.5 WF	22.0 WF	28.6 PO	27.3 PO
	13.1 TF	26.5 WF	23.0 WF	29.0 PO	29.0 RF

Notes:

In b), columns (2) to (5), tube strengthened externally by welded straps.
Columns (4) and (5), additional weld reinforcement. Details of joint as shown in Fig. 2.

Grout PCX: Rapid hardening Portland cement with Conbex, water-cement ratio 0.3.
Grout CF: Ciment fondu, water-cement ratio 0.27.
Types of Failure: PO rod pulled out of joint.
TF tube failure
WF weld failure } secondary failures.
RF rod failure

---

[2]) Manufactured by Chemical Building Products Ltd., Hemel Hempstead, Herts, England.

Further tests utilised tubes with an internal helical groove to improve the adhesion. This had the effect of weakening the tubes and all specimens, with both types of grout, failed in the tubes. To prevent this, in order to determine the actual strength of the joints, straps were welded along the outside of the remaining grooved tube specimens, but these now failed in the weld. A further four specimens (two with each type of grout) of grooved tubes with external straps and additional strengthening of the weld, were tested at the age of 28 days. As may be seen from table 1, in comparison with the load-strain characteristic of the type of rod used, Fig. 4a, the failure loads of these joints

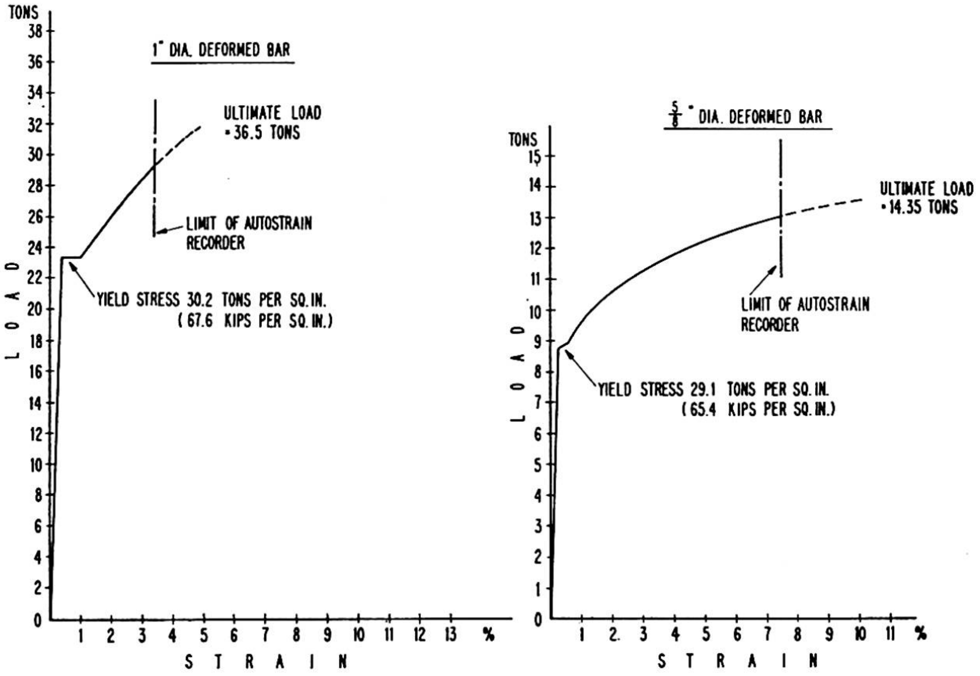

Fig. 4a) Fig. 4b)

Fig. 4. Tension Tests on Reinforcement.

was above the elastic limit of the rod. It is not considered that these constitute true joint failures, since the strains associated with steel yield are obviously incompatible with joint cohesion.

It appeared as a result of these tests that a satisfactory joint had been achieved, but the actual strength using Grout PCX in untreated tubes had not been found since most of these tests resulted in weld failures. Further investigation, using untreated tubes, was therefore desirable, since grooving the tubes not only weakened them but was very expensive. As an alternative to grooving, roughening the internal surface by means of scattered weld spots was tried. This was much cheaper and did not weaken the tube.

The further series of tests, which are still in progress, were planned to investigate;

a) the effect of inaccurate placing of the rod in the tube. In practice, it is liable to be offset from the centre due to constructional errors.

b) determination of the minimum grip length for full joint strength.

c) comparative tests with $^5/_8$ inch diameter rods in correspondingly smaller tubes.

d) testing a set of identical specimens at intervals over a long period in order to investigate the effect of time on the joint strength.

The results in table 2 indicate that placing the rod off-centre in the hole had no significant effect on the strength and also that roughening the tube with weld spots had little effect on the failure load, but increased the load at which the first cracks appeared in the jointing material. Since this load is above the yield point of the rod in all cases, these joints appear to have increased ability to resist the effects of steel yield.

A few tests with $^5/_8$ inch diameter deformed bars using 6 inch joint lengths with Grout PCX which are the first specimens of a long term series gave the results in table 3. In all these tests, except one, the failure load was in excess of the yield strength of the rod (about 9 tons, as shown in fig. 4b) and the beneficial effect of internal roughening of the tubes is again apparent. The tests at 6 and 9 weeks age are not significantly different in result from the comparable short term tests.

Table 2. Failure loads in tons

$l = 9$ inches. Grout PCX. 1 inch diameter deformed rods

Age at test days	Untreated tubes		With weld spots Rod central
	Rod central	Rod offset	
3	26.6 (23.7) WF 24.2 (23.0) PO	25.4 (23.0) WF 28.6 (23.0) TF	29.4 (26.0) TF 29.2 (26.0) TF
7	29.3 (22.0) TF 26.7 (22.5) WF	29.1 (22.0) TF 25.0 (23.0) WF	26.8 (26.0) WF 29.0 (25.0) RF

Figures in brackets are the load values at which the first cracks appeared in the jointing material. Details of joint as shown in Fig. 2.

Table 3. Failure loads in tons

$\frac{5}{8}$ inch diameter deformed rods. 1.34 inch external diameter tubes (10 swg) $l = 6$ inches. Grout PCX

Tube surface	Untreated		Weld spots		Untreated	
Age at test	3 days	7 days	3 days	7 days	6 weeks	9 weeks
Failure loads (tons)	11.5 PO 10.5 PO 12.2 PO	11.9 PO 11.6 PO 7.4 PO	13.3 PO 12.8 GS[1]) 13.3 PO	13.1 PO 13.6 RF 13.2 RF	10.6 PO 12.9 RF 12.4 PO 14.1 PO	13.5 RF 9.0 PO[2]) 12.2 PO

[1]) Slipping of the machine grips. [2]) Defective joint with voids.

Conclusions

On the basis of the short term tests the load factor based on the first signs of joint failure in comparison with a design stress of 30,000 psi is greater than 2.0 for both the 1 inch diameter rod with l = 9 inches and the $^5/_8$ inch rod with l = 6 inches, which amounts in fact to the ratio of yield to permitted stress. It appears that the best design will utilise Grout PCX, and tubes internally roughened with weld spots, to resist the first effects of steel yield. Although the continued tensile strength of these joints over a long period has yet to be established, their use is already of advantage in the construction of buildings made of precast concrete members, by permitting the rapid erection of frames, even when the design is such that the final loading condition of the columns does not require the full strength of the joints.

The tests were carried out in the laboratories of the Department of Structural Engineering, Manchester College of Science and Technology. The authors acknowledge the assistance of E. C. Garner and M. E. Phipps.

Reference

1. L. A. Igonin: "Glued Joints for Reinforcing Bars and Precast Units". Gidroteknicheskoe Stroitel'stvo, 1964 (2), 16—21.

Summary

The development of a cheap, easily and rapidly made system of jointing precast concrete columns is described, in which the full strength of the reinforcement is attained at an early age. The projecting reinforcement of the upper member is inserted into tubes welded to the reinforcement of the lower member and bonded by means of expanding cement grout as shown in Fig. 3, the bar projection being only 9 diameters long.

Résumé

On décrit le développement d'un système d'assemblage des piliers en béton préfabriqués qui présente l'avantage d'être bon marché, rapide et d'exécution facile; en outre, la pleine résistance de l'armature est atteinte dans des délais très brefs. A l'armature de l'élément inférieur sont soudés des tubes dans lesquels on introduit le prolongement de l'armature de l'élément supérieur conformément à la Fig. 3; la liaison est assurée par un coulis à base de ciment expansif. La partie saillante de l'armature supérieure n'a que 9 diamètres de longueur.

Zusammenfassung

Die Autoren beschreiben die Entwicklung eines neuen Verbindungssystems für vorgefertigte Pfeilerelemente, das folgende Vorteile aufweist: billige, rasche und einfache Herstellung, zudem wird die volle Tragkraft nach kurzer Zeit erreicht. Die Armierung der oberen Elemente wird dabei in Rohrstücke eingeführt, die auf die Bewehrung der unteren Elemente aufgestülpt und angeschweißt sind. Die Verbindung wird erzielt durch Vergießen des Zwischenraums mit einem expansiven Zementmörtel (siehe Fig. 3); dabei haben die überstehenden Enden der Armierung nur eine Länge, die dem Neunfachen des Durchmessers entspricht.

Leere Seite
Blank page
Page vide