Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 73/1/73/2 (1995)

Artikel: Repair of an existing prestressed concrete shell of a mill in Egypt
Autor: Youssef, Magdi R.A.
DOI: https://doi.org/10.5169/seals-55256

Repair of an Existing Prestressed Concrete Shell of a Mill in Egypt

Réparation d' un voile en béton précontraint en Egypte

Reparatur eines vorgespannten Schalentragwerks in Ägypten

Magdi R.A. YOUSSEF
Consultant Civil Engineer
Misr Concrete Development Co.
Cairo, Egypt

Magdi R.A. Youssef, born 1941, received his civil engineering degree at Ain Shams University in Egypt in 1964. He is now the head of the technical design office of a leading construction company in Egypt. He is a committee member for the Egyptian Code for Reinforced Concrete.

SUMMARY

The repair and strengthening of an existing prestressed concrete building has been performed by careful inspection of each element of the building, structural design and the choice of the best repair method. Use of external prestressed tendons and flat jacks has been mostly preferred.

RÉSUMÉ

La réparation et le renforcement d'une construction existante en béton précontraint a été réalisée sur la base d'une inspection attentive de chaque élément de la construction, du calcul statique et de la meilleure méthode de réparation. L'utilisation de câbles de précontrainte extérieure et de vérins plats a été choisie.

ZUSAMMENFASSUNG

Die Reparatur und die Verstärkung eines bestehenden vorgespannten Betonbauwerks wurde auf Grund einer genauen Untersuchung jedes Bauwerkselementes, der konstruktiven Bemessung und schliesslich der Auswahl der besten Reparaturmethode vollzogen. Es wurde vor allem Vorspannung und Spannpressen verwendet.

1-INTRODUCTION

Buildings constructed in EGYPT in the forties and fifties, specially heavy industrial factories & bridges have been exposed to environmental changes & different weather conditions along with changes of the levels & chemical properties of underground water . Such factors together with lack of regular maintenance, improper rainwater drainage systems & inadequate isolation of roofs have affected the buildings. Since then, regular examination of important establishments has proved to be of great importance to detect damage before it is too late. New methods of repair & and new materials were introduced to make buildings more durable. This paper deals with the repair done to a spinning & weaving factory constructed in 1956 in Egypt and has been affected by the aforementioned factors. In 1990 it was necessary to perform the repair work without suspending work and production in the factory.

2-DESCRIPTION OF THE PROJECT

A prestressed concrete shell 164.9 x 173.9 m. for a spinning mill that was constructed and later repaired by "The Misr Concrete Development Co.". The roof consisted of concrete shell 7 to 25 cm. thickness supported on truss diaphragms with post tensioned tie beams in the longitudinal direction and on valley beams in the short direction. There was also a concrete flat plate slab hanging from the shell roof by high tensile steel bars. The shell was supported on 64 columns hinged up and down as link members and 16 fixed columns on axes 7 and 8.The mill foundations were supported on piles. Fig.(1).

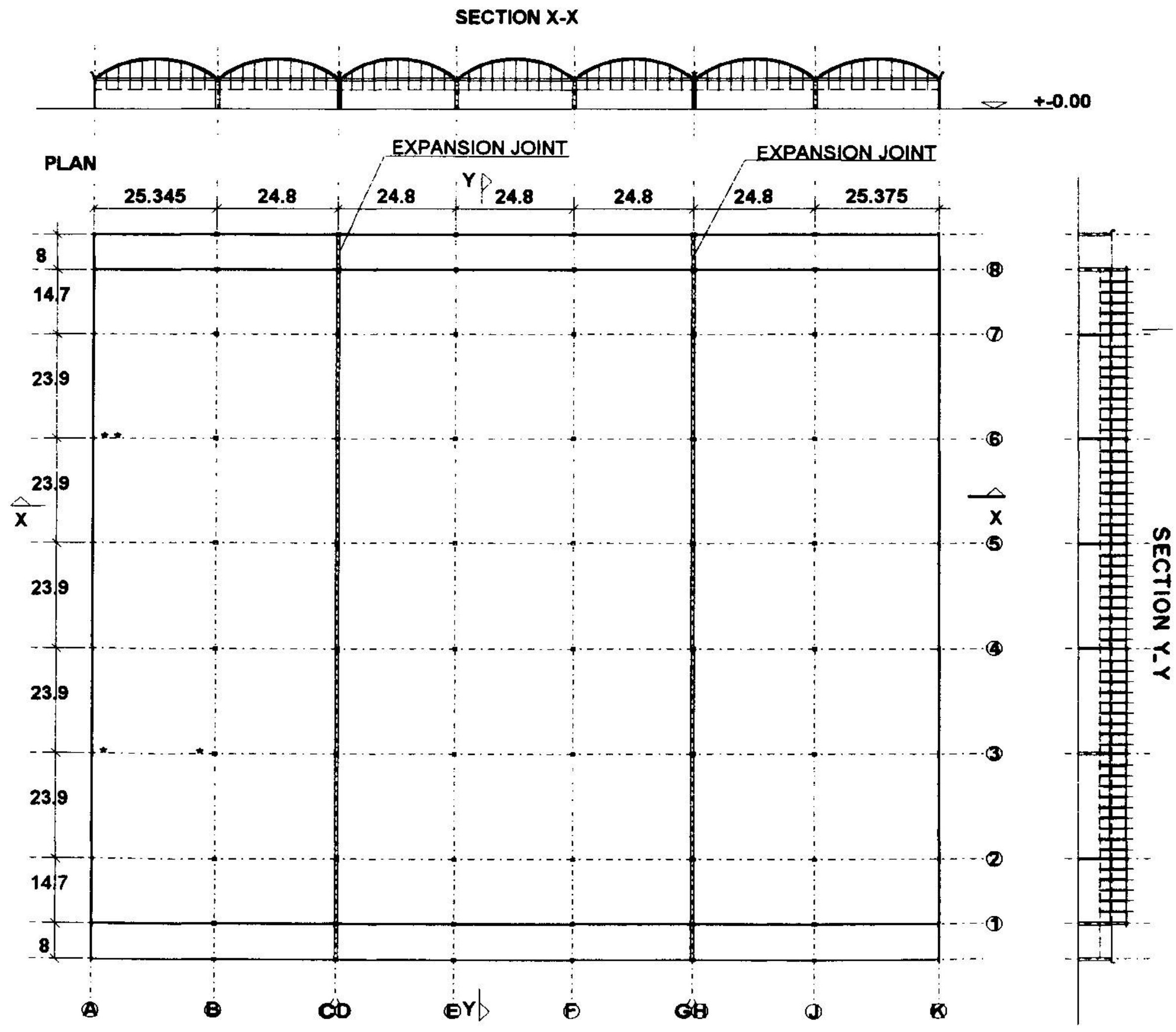


Fig. (1)

LEGEND

* * Totaly damaged tie beam

* Partially damaged tie beam

3-INSPECTION OF THE STRUCTURE

3-1 Inspection procedure followed:

3-1-1 All the cracks or fractures, damaged concrete, broken or rusty rebars and prestressing tendons were indicated on specific drawings for each element.

3-1-2 Site survey for the columns concerning the relative displacement between the lower and the upper edges as well as survey for the tie beams and the valley beams.

3-1-3 Scratching at random spots, (10x10x3 cm.) to show the condition of the prestressing tendons. Spots with undamaged tendons were directly covered by epoxy mortar.

3-1-4 Checking of two pile caps to investigate the condition of the foundations.

3-1-5 Defining the strength of the existing concrete for all elements by non destructive tests.

3-1-6 Checking the roof isolation and the expansion joints.

3-2 Inspection results

The isolated layers and the expansion joints filler were damaged causing leakage of rain water. Inspection of the roof showed presence of cracks, damage in concrete parts of the shell and corrosion of reinforcing bars and prestressing cables. Two tie beams were seriously damaged.

4-DESIGN

A finite element model for the whole structure (shell and columns) has been carried out by "Europe Etudes Gecti" of France [1] to check the stresses and displacement of the actual structure under permanent, superimposed loads and the effect of additional prestressing on shell element. The checking of the permanent and the superimposed loads on the existing structure showed that there were residual tension stresses (about 1MPa) at the tie beams and valley beams that might have been one of the causes of the cracks. Several repair methods and systems have been thoroughly studied and considered. Using external prestressing with flat jacks proved to be the most suitable system in this case. To minimize the displacement and the stresses at the ends of the columns, especially at the fixed columns during prestressing operation, two steps were followed using flat jacks inserted in the expansion joints. Fig.(4).

4-1 Percentage of the force on the tie beam due to an applied prestressed force

The finite element models show that 85% of the total applied prestressed forces are carried by the tie beams.

4-2 Strain value and stresses on columns due to displacement

step no.	distance from center line of building (m.)	87.5	62.5	37.5	12.5
	Column dimension (cm.)	40x75	75x75	40x75	75x75
1	Flat jack displacement (m.) = 0.005	0.005	0.005	0.000	0.000
2	Prestressed force (KN) = 1300	-0.00694	-0.00353	-0.00512	-0.00171
3	Flat jack displacement (m.) = 0.009	0.00206	0.00547	-0.00512	-0.00171
4	Prestressed force (KN) = 1300	-0.00957	-0.00305	-0.01023	-0.00341
	Displacement without flat jack prestressed force (KN) = 2600	-0.02387	-0.01705	-0.01023	-0.00341

Table (1) Columns displacement in meters.

Strain = stress / E = 0.85 P / A E

P = prestressed force

A = tie area = 0.75 x 0.30 = 0.225 m^2

E = Young's modulus (taking into consideration the age and strength of the concrete)

Strain / KN = 0.85 / 0.225 x 36 x 10^6 = 1.049 x 10^{-7}

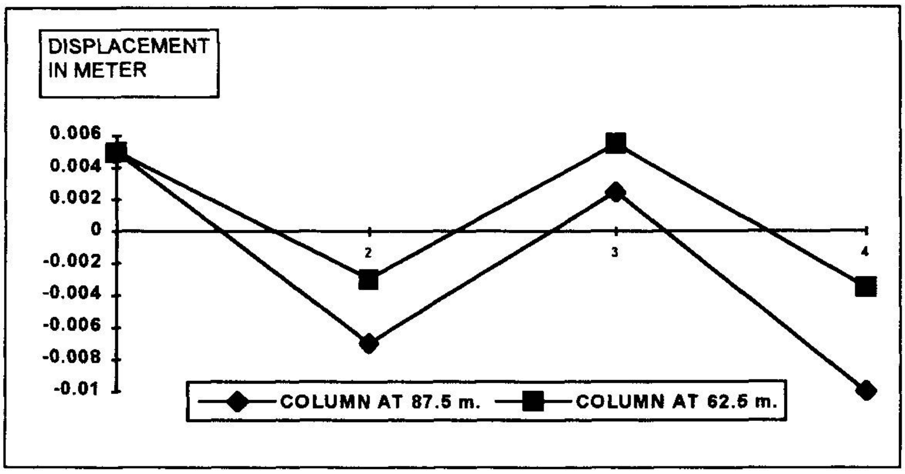


Fig.(2) : Displacement of the columns

From the final calculation of the displacement the stresses on the columns were calculated

5- REPAIR AND STRENGTHENING

5-1 Shoring

A suitable system of shoring was erected under all the damaged parts for the safety of the building and to allow the production to continue in the mill.

5-2 Repair of cracks

Epoxy resin with two components without solvent was injected for re-establishment of the structure's monolithism, for protection of the reinforcement bars and prestressed tendons against corrosion and for water proofing of the structure.

5-3 Repair of damaged concrete

Mortar with epoxy resin as a base was applied for the roof. Expansion joints were filled around the flat jacks with pure cement mortar with admixture to minimize shrinkage.

5-4 Protection of tie beams at the damaged parts

Before strengthening, repair of the damaged concrete was done for the tie beams where the concrete was damaged over a part of the total length. This repair consisted of constructing a concrete jacket that was post tensioned using mono-strand anchorage of compensated type. This jacket overlapped an undamaged part of the tie beam. Fig.(3)

5-5 Installation of the flat jack

The dished surfaces of the flat jacks were filled and leveled with a hard setting epoxy resin mortar. The copper piping, the valves and the manometer were connected to the flat jack. The flat jacks were then installed inside the expansion joints in the structure at the intersection of axes C,D and G,H with the axes from 1 to 8. The flat jacks were connected to one pump. Fig.(4) Detail (3)

5-6 Prestressing cables

Tie beams and valley beams were strengthened by external prestressing cables, consisting of unbonded plastic sheathed strands. All strands of one cable (4K15) were threaded in one steel tube of 76 mm. external diameter, and 2mm. thick. The cables were hung by temporary steel supports on the tie beams or the valley beams and were ended at concrete anchorage blocks on the outer grid lines. (For tie beams at grid lines A, K and grid lines from 1 to 8,for valley beams at grid lines 1,8 and grid lines from A to K). Fig (4).

PLAN FOR JACKET

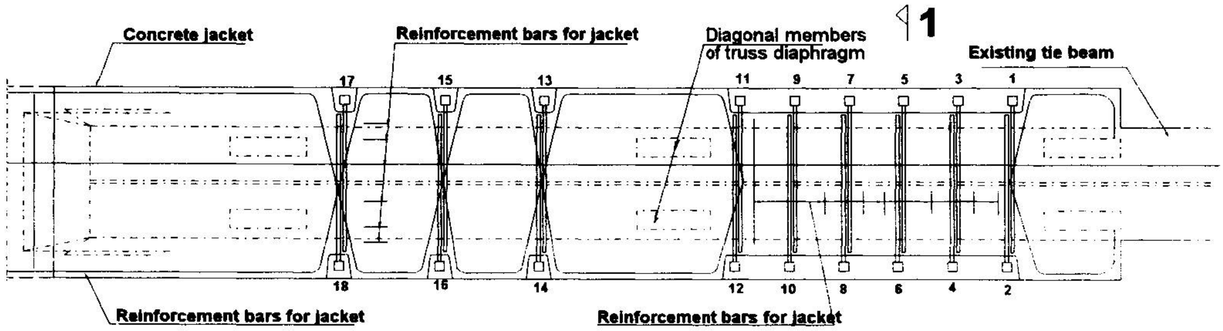
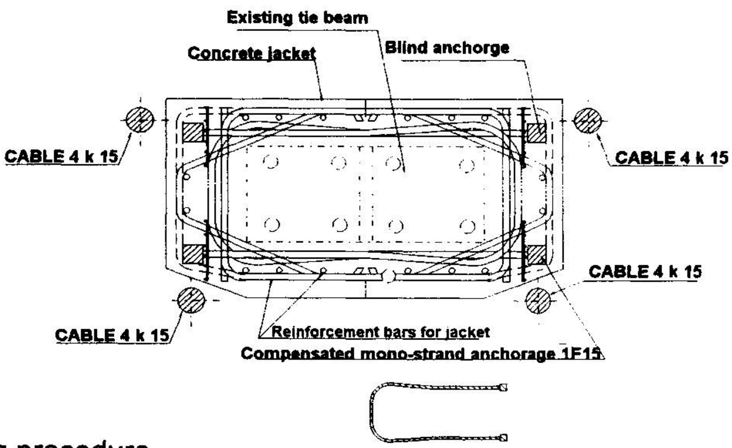


Fig.(3)

SECTION 1-1



5-7 Strengthening procedure

The following steps were followed

5-7-1 Tensioning of the strands of each tendon up to jacking pressure 50 bars.

5-7-2 Injecting the prestressing cables with cement grout.(the prestressing strands were individually greased and sheathed)

5-7-3 The first stage of flat jacks loading : each flat jack was inflated by 5 mm. they were then shimmed by wedges to maintain the inflation.

5-7-4 The first stage of tensioning of prestressed tendons by half the prestressing force up to 1300 KN. At this stage structural deflections were measured to check the assumed value for Young's modulus of elasticity for the concrete.

5-7-5 The second stage of flat jacks loading : each flat jack was inflated by 9 mm. then they were shimmed by wedges.

5-7-6 The second stage of tensioning of tendons by full prestressing force up to 2600 KN.

5-7-7 Injecting the flat jacks by epoxy resin.

5-7-8 Tensioning of valley beams tendons.

5-8 Isolated layers

All the isolated layers over the valley beams were renewed to protect the shell roof .

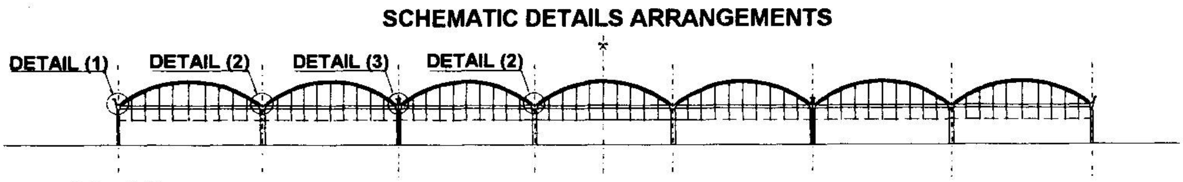
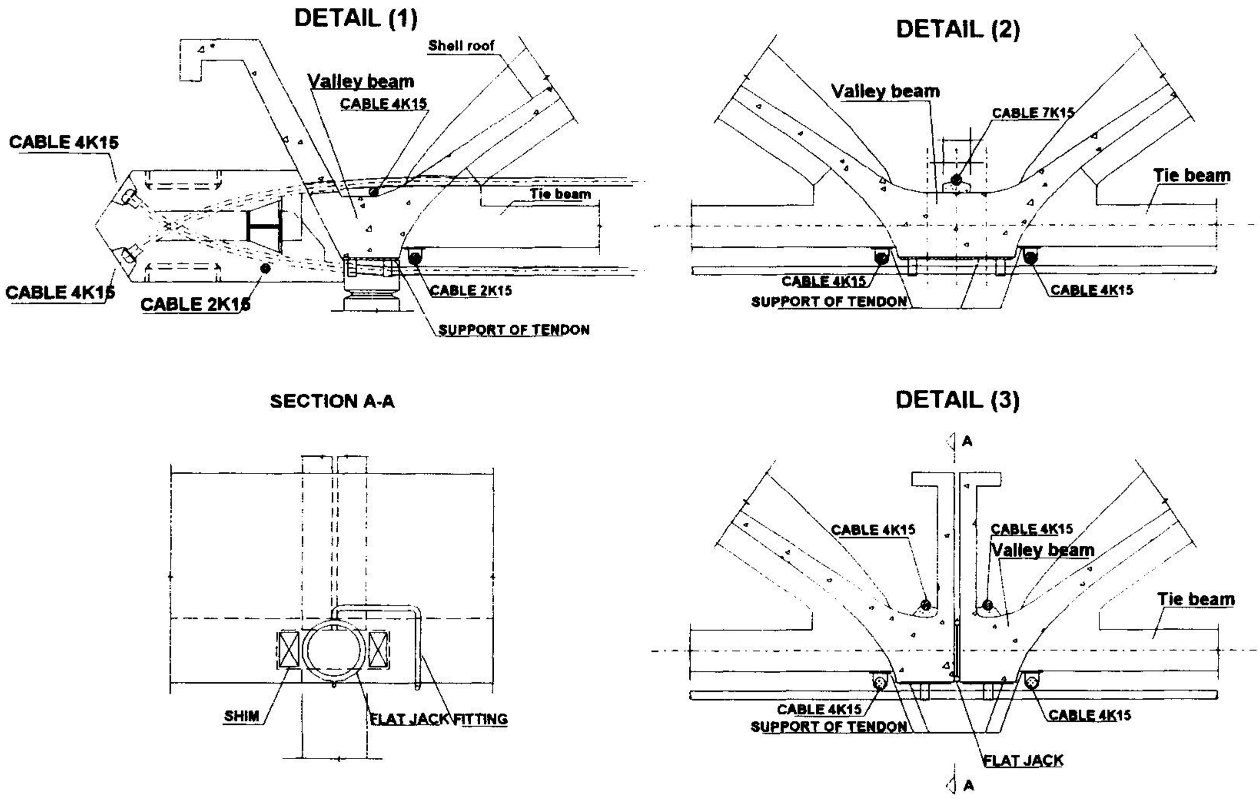


Fig.(4)



6-CONCLUSION

Repair of existing concrete structures using external prestressing forces is considered a procedure that needs a high degree of accuracy .Measurement of deflections and displacement during all stages should be under strict control. If the calculated displacements are different from the measured ones, the tensioning forces for the prestressing of tendons and the inflating pressures for the flat jacks must be modified accordingly

REFERENCES

[1] A.G. LABIB and M.H.C. ADIB ,finite element model for the shell roof of Mill in Misr Mehalla Co. Europe Etudes Gecti of France 1990