Application of a New Water-Structure Interaction Support System for Existing Bridges

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Abstract: A new temporary supporting system, which has been developed by the author, is applied to temporarily support Al-Tabia existing bridge over a canal located at the route required for the transportation of the abnormal heavy packages to Abu Quir power station, Egypt. This new system depends mainly on water-structure interaction and it is approved by the Egyptian general authority of roads, bridges and land transportation (GARBLT) to be used for the transportation of heavy loads over existing bridges after it was developed and proven to be very successful- both analytically and experimentally by the author. The assessment, strengthening and health monitoring of the bridge is presented. The dynamic test results have been used as a monitoring tool to prove that the bridge have not been damaged by the additional imposed abnormal loads.

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1. Introduction

Al-Tabia Bridge is an existing bridge located in Abu Quir, Alexandria, Egypt where a new power station is decided to be built. This bridge has been designed for a load of 70 Ton which is extremely small compared to the abnormal heavy weights of equipments -that exceed 500 tons- required for this station. The bridge passes over a canal that makes the conventional temporary supporting techniques are very difficult due to the inaccessibility to the structural components. Moreover, it is very difficult to accurately assess the strength of the different structural elements of the bridge due to the lack of design drawings. As a result, a new technique that mainly depends on water-structure interaction is decided to be used as a temporary supporting system. This main concept of this technique which has been developed and verified by the author, [1], is to depend on the uplift force of the water to impose reversal forces on the bridge to counteract most of the loads expected from the abnormal heavy loads. Moreover, the process of temporarily coupling the bridge deck with a barrage supported by the water uplift, if accurately designed, results in a combined structure that has an effective combined rigidity which is highly above the bridge deck rigidity decreasing the deformations imposed by the loads. In the following parts, the details of applying this system to Al-Tabia Bridge are summarized.

Details of the abnormal load

The main features of the loading system are illustrated in figure 1 and may be summarized as follows:

- Transportation on 1trailer x 3files x 16 axles, Each File contains 4 wheels
- Weight of load is 404 Ton, Total Load is 510Ton
- Block ground load is 4.56 Ton/m2.

Description of the bridge:

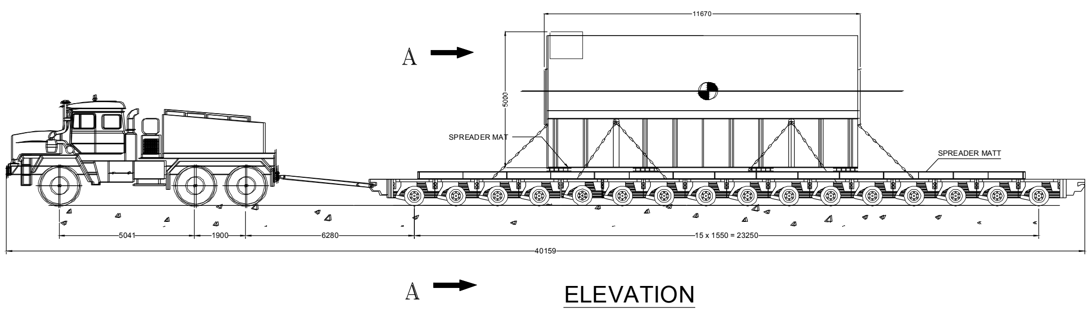
The bridge was inspected in the site to check its overall conditions. It is composed of 3main spans, 9.6m long each. The deck is slab-girder type. No design drawings are available and the general layout of the bridge is illustrated schematically in figure 2. The bridge was visually inspected and it was concluded that its general condition is very poor as illustrated in pictures 1 to 3. As a result of the visual inspection, and due to the lack of design information, it was decided to use the water-structure interaction technique described above, as a temporary support for this bridge.

Analytical study:

The bridge deck was analyzed under the effect of total load of the package including the weight of the trailer as shown before. The concrete Young's modulus was assumed 250 ton/cm^2 and the analysis was performed by the computer software SAP90.

The grillage method was used in the analysis of this bridge, [2]. The longitudinal main girders were modeled with the properties of a T-section and the slab was modeled as lumped transversal beams every 1.0-meter.

The water uplift was modeled as spring forces distributed all over the area of the barrage. Steel beams are used to distribute the loads on the barrage and they were modeled with their actual stiffness. Figure 3 shows the analytical model for the bridge deck, the steel beams, the props, the barrage and the water uplift.



TRAILER	1 X 3 X 16	
TRAILER CAPACITY	672	TON
WEIGHT OF LOAD	404.00	TON
WEIGHT OF TRAILER	84	TON
WEIGHT OF AUX STEEL	22.50	TON
TOTAL	510.50	TON
LOAD/ AXILE FILE	31.90	TON
BLOCK GROUND LOAD	4.56	t/sq.m

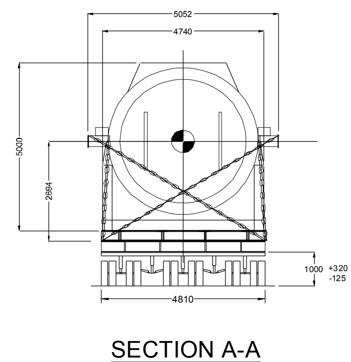


Figure 1: Outlines of the loading

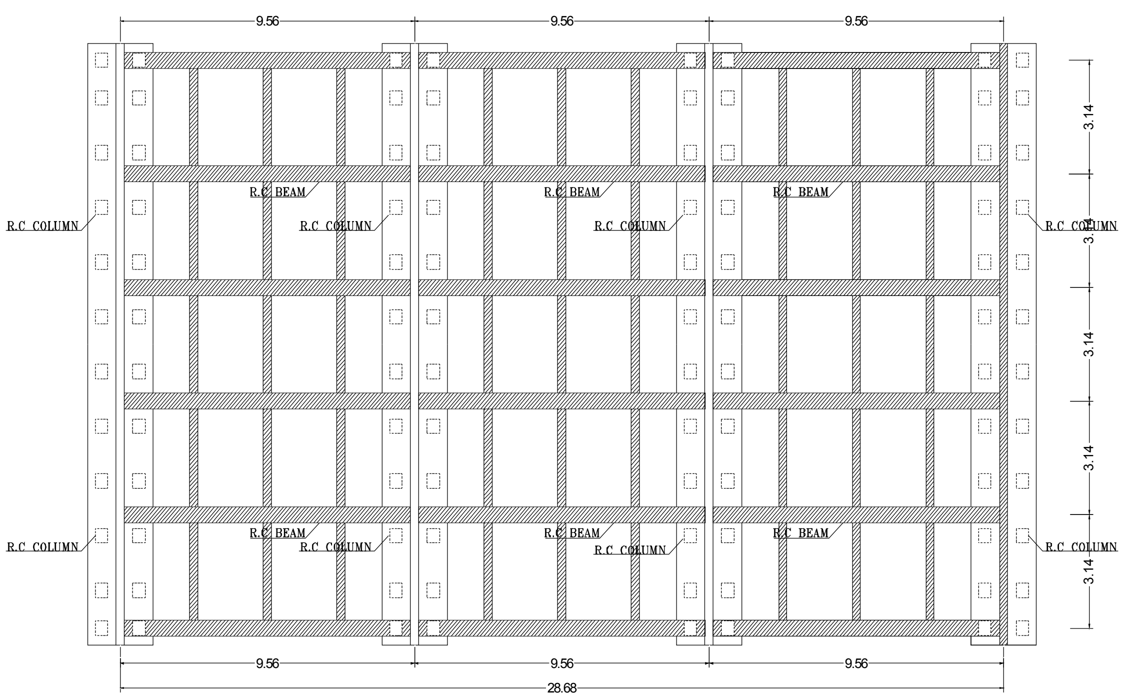
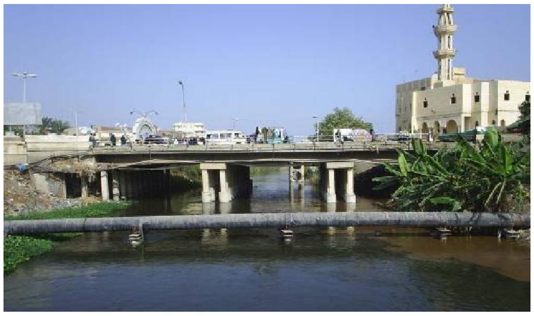
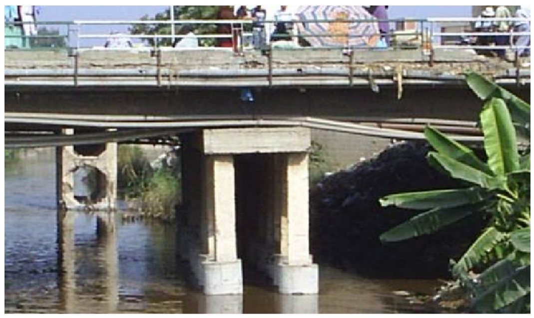


Figure 2: Layout of the



Picture1: General Layout

Picture 2: General View for the Piers



Picture 3: Close View of the Piers

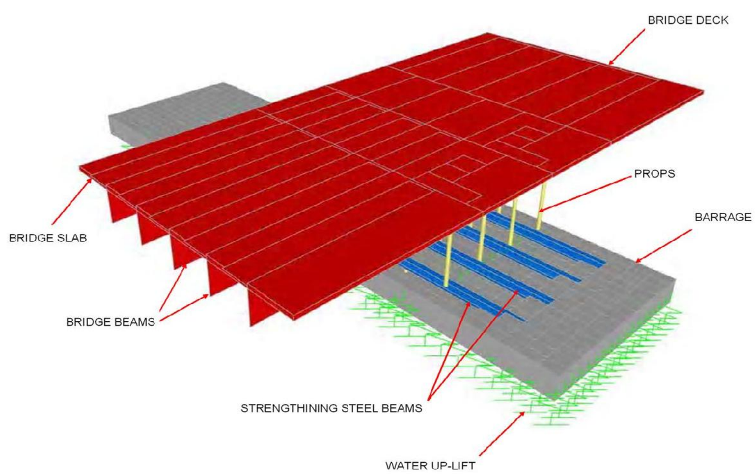


Figure 4: Analytical Model

Description of the temporary water supporting system

Based on the analysis described above, the main components of the temporary supporting system were chosen as follows:

1- One rigid barrage under each span 12.5 long x 6.5wide x 1.9 deep, with enough area to create uplift with the amount calculated to withstand the expected applied heavy loads.

2- 150 Steel props distributed under the main girders and the deck slab. These props were conservatively distributed under the slabs as one prop for each 1m square. The vertical load capacity of each prop is 3 tons.

3- Steel beams to carry these steel props, IPE400.

4- 12 Hydraulic jacks under each span distributed at specific points between the pontoons and the bridge deck. Hydraulic pressure was applied on these Jacks resulting in pushing down forces on the pontoons and jacking up forces on the deck. Total jacking force at each span is 130 Ton.

5- Spiral padding under each span to control any variation in the water level.
6- Vertical steel pads composed of 4 IPE100 vertical beam with top and bottom plates 600 x600 x 20 mm
7- Hydraulic pump was used to apply the required pressure on the jacks.

Figure 4 shows the details of this system. Pictures 4 to 10 illustrate some details of the process.

Health monitoring of the bridge:

The safety of the bridge due to this loading has been checked using three methods:

1. The deflection measurements
2. Visual inspection after each transportation
3. The dynamic modal tests and

The results of each health monitoring system are briefed in the following part:

1- Deflection measurements:

Surveying process was carried out for the bridge during the movement of the load. Figure 5 shows the observation points on-top of the bridge deck with the deflection values at each point before and after the movement. A maximum deflection of 2mm was observed at point (8) during the movement. All points rebounded back to its position as the load passed away from the bridge as shown in figure5.

2-Visual Inspection:

All the elements of the bridge were thoroughly inspected by a team from all parties involved in the project. All of the elements found unaffected by the works.

3-Dynamic Test

Dynamic tests were conducted before and after passing the heavy loads to address any changes in the global rigidity of the bridge. This test was applied on the bridges at two stages. The first stage was conducted before the strengthening works; the second test was conducted after the transportation of the package. All the dynamic tests were conducted by The Construction Research Institute, of the Ministry of Irrigation. Figure 6 illustrates a flow chart for the process of recording the vibration of the deck after exciting it using a normal truck moving to a specified speed leaving the deck to normally vibrate. Table 1shows the test characteristics. Figure 7 shows the position of attached accelerometers on the plan of the bridge deck. Picture 11 shows the used truck during the test and picture 12 illustrates an accelerometer attached to the girder of the deck

3.1 Test Setup

Data was recorded for each loading condition to achieve acceptable accuracy. The sampling rate was 200 Hz. and the sampling time was variable depending on the conducted test. The recorded data were filtered using band pass filter of cut-off frequencies of 5 and 50 Hz., respectively. Figure 8 illustrates the response time record for one channel at the first bay.

3.2 Results of the dynamic test

The frequency of the bending modes for both the first and the last tests are identical with a value of 13.28 Hz. As a result, i.e. the global rigidity of the bridge was not affected by the transportation of the package using the suggested water-structure technique for the temporary support system.

Conclusions:

- A new temporary supporting system, which has been developed by the author, is applied to support Al-Tabia existing bridge over a canal located at the route required for the transportation of the abnormal heavy packages to Abu Quir power station, Egypt.
- Analytical model was conducted to determine the necessary dimensions and number of all the components of the system.
- The details of the new supporting system are illustrated.
- Health monitoring of the bridge deck was conducted using; a- deflection, b- visual inspection and c- dynamic test
- The results of the health monitoring methods indicated that the process was very successful.

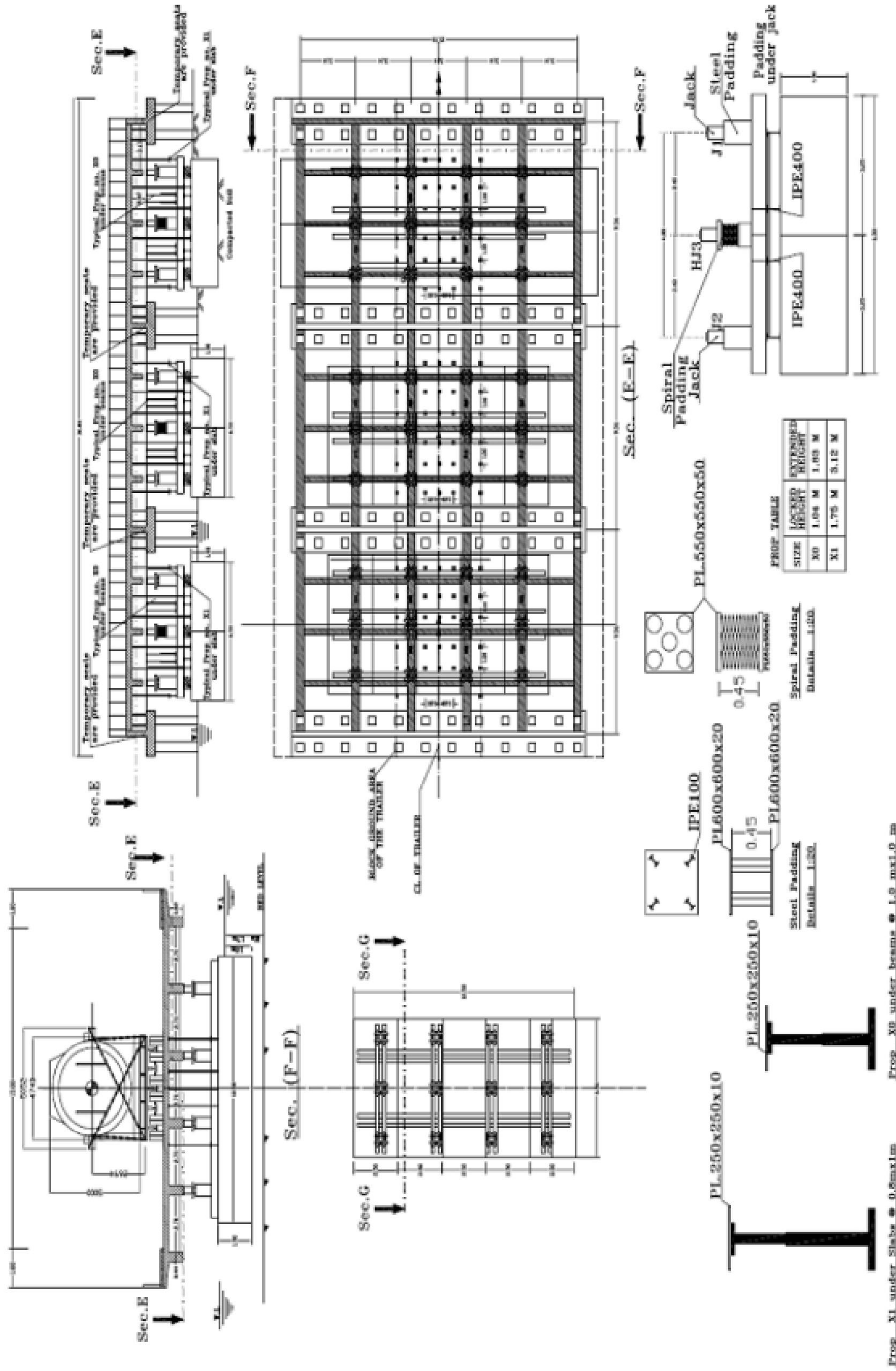


Figure 4: Details of The supporting System

Picture 4: General view of the barrage

Picture 5: Jacking up the deck

Picture 6: Propping the deck

Picture 7: Precise eveling

Picture 8: General view of the package

Picture 9: General view of the system

Picture 10: During transport

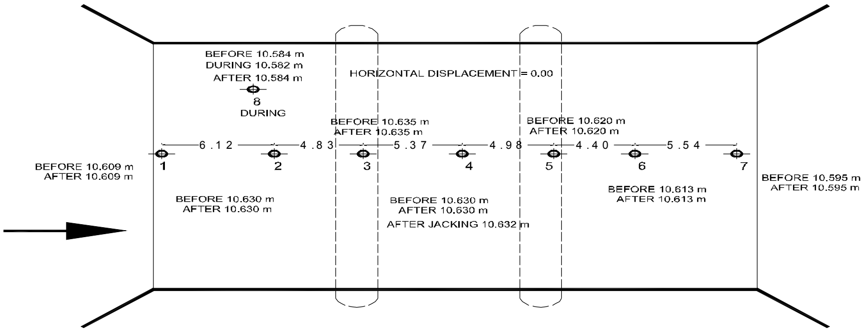


Figure 5: Observation points on the bridge deck

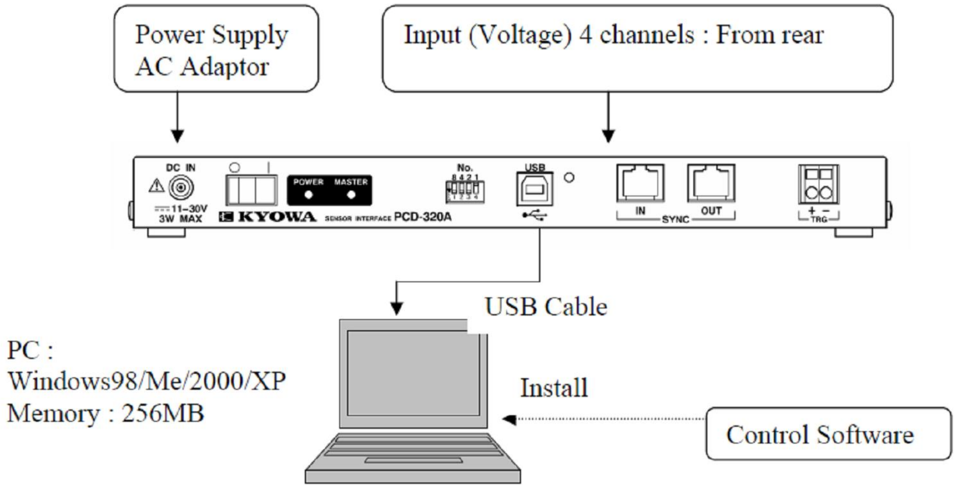


Figure 6: flow chart for the process of recording the vibration of the deck

Table 1: Test Characteristics

Sampling Rate	*200 sample / sec*
Sampling Time	25 sec
Cutoff Frequency	50 Hz
Number of records	5

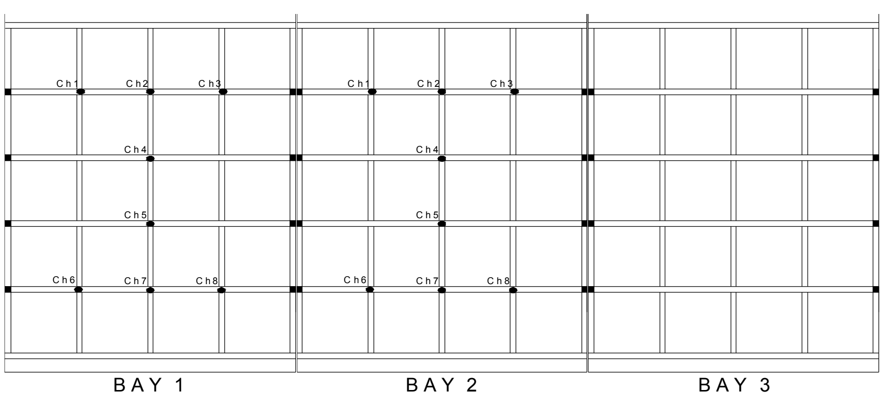


Figure 7: Location of the accelerometers on the bridge deck

Picture 11: Exciting truck

Picture 12 fixing the accelerometer

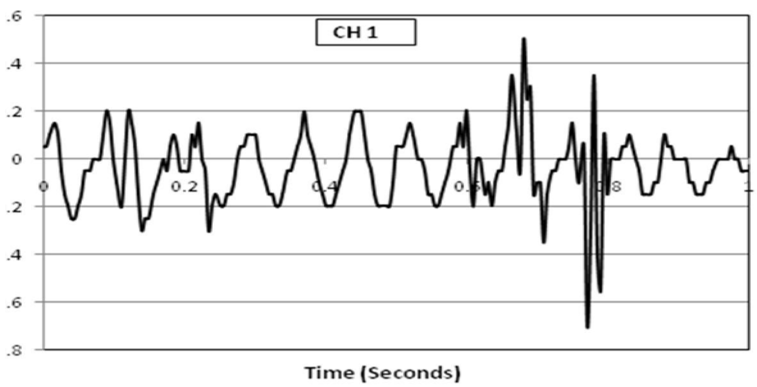


Figure 8: Sample of Response time record

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