

Repair of the damaged dock and the auction hall of the fishing harbour of Sidi Daoued

Abstract

A port is a place located on the seacoast, on the banks of a lake or on a watercourse and designed to accommodate boats. A port can fulfill several functions, but above all it should be used to house ships, especially during loading and unloading operations. It also promotes refueling and repair operations. In this paper, an experimental study was conducted on the fishing harbour of Sidi Daoued which has structural disorders. Indeed, a reinforced concrete paving study was done in order to choose the suitable reinforcement. The bollards were calculated to be able to resist for ships of various tonnages. Thus the bollards, their dimensions and anchoring, and the berth structure itself shall be designed for a certain minimum loading. The test results were analyzed to identify the various causes of damage of the dock in order to offer adequate compensation method and protection against future attacks. The jacketing method has been proposed for the reinforcement of beams and columns of the auction hall.

Keywords: fishing harbour, bollards, dock, auction hall, repair, damage, jacketing method

Volume 4 Issue 5 - 2018

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Received: November 11, 2018 | **Published:** November 21, 2018

Introduction

A fishing harbour is a port located by the sea, water body or river and reserved for boats or fishing vessels. Thanks to its infrastructures, it allows and facilitates the landing of their load. The fishing harbour is responsible for managing all activities related to fishing and fish marketing. The different phases concern the reception of fishing vessels, fish, its treatment, its packaging in the most varied forms, its marketing and, finally, its shipment to places of consumption. Depending on whether one or the other of the functions is predominant, the port is located near the fishing grounds or near the places of consumption. In the latter case, particular attention must be paid to the network of land and commercial links. The current tendency is to favor the first landing of the fish in fishing ports near the fishing grounds, then to redirect, possibly in containers, the fish towards ports near the places of consumption which become above all platforms of transformation and marketing. Fishing harbors are the most numerous in the world, and are frequently those with the smallest dimensions. Their dimensions fluctuate according to the boats they welcome: the high-sea trawlers leaving for several weeks will need, moreover, of dock space when they come back to unload their cargo, while the small fishing boats leaving by day will need to be able to unload quickly for the auction. The infrastructure is simpler than for a commercial port: some wharves or pontoons, a refueling station, and a way to sell the fishery product (nearby market), and possibly treat it before sale if it was not done on the boat. Many fishing harbors are also the source of major impacts on the physical and biological coastal environment.¹ The geographical position and geometry of harbor basins and jetties determine the qualities of a port and influence the following parameters:

- I. Protection:** the port can be opened or have a natural or artificial shelter through a pier or breakwater. The port can be closed or complex access when the waves and / or the wind have a specific orientation. The speed of ships is regulated in and around the ports. Intra-port traffic should not generate significant waves.

- II. Depth:** the available depth, depending on the time of the tide, determines the size of the boats that can enter according to their draft. For large ports, the depth is maintained by regular dredging of the bottom or access channels. To maintain sufficient depth, some ports have locks or thresholds; the draft of the ship is also affected by the phenomenon of overfilling. The deepest ports in the world reach 30 m, but 15 m is a more common figure for commercial ports, and 2 to 6 m for marinas.

- III. Beacons:** the entrance to a port must be identifiable day and night, and by non-visual means in the fog. Beacons are based on natural landmarks, buoys or beacons using the lateral or cardinal device, lights and beacons, some equipped with racon device. The present paper presents the results of an experimental study carried out in the fishing harbour of Sidi Daoued. The test results were analyzed to identify the different disorders in the different elements of the fishing port and examples of their application. Jacketing of the columns and beams is the method of repair and reinforcement which was chosen based on the nature and degree of importance of disorders recorded during diagnosis.

Presentation of the project

Definition of the harbour

A port is a place located on the seacoast, on the banks of a lake or on a major watercourse, and intended to accommodate ships and ships. Fishing harbours are the most numerous in the world, and are often the smallest. Their dimensions vary according to the boats they are receiving: high seas trawlers leaving for several weeks will need more docking space when returning to unload their cargo, while small day-fishing boats will need to be able to unload quickly for the auction. Table 1 gives the near water fishing harbours in Tunisia and their dates of construction. Among these harbours, the coastal port of Sidi Daoued which is located in the western coast of the peninsula of

Cape Bon and to the north of a bay about 2 km wide and 1,3 km deep. Figure 1 presents a general view of the harbour of Sidi Daoued whose construction was completed in 1983. General information on the Sidi Daoued fishing harbour are given in Table 2.

Table 1 Near water fishing harbours in Tunisia

Governorate	Harbour	Date of construction
Bizerte	Sidi Mechreg	1990
	Cap Zebib	1997
	Ghar el melh	1980
Nabeul	Haouaria	1998
	Beni Khair	1984
	Sidi Daoued	1983
Sousse	Hergla	1984
Monastir	Bekalta	1986
	Sayada	1965
	Teboulba	1987
Mahdia	Chebba	1976
	Salakta	1985
Sfax	Louza-louata	1985
	Mahres	1987
	Skhira	1975
	Kratten	1987
Attaya	Attaya	1992
Gabes	Zarrat	1985
Mednine	Boughrara	1986
	Ajim	1985
	Houmet souk	1948
	El Kef	1988

Table 2 General information on the Sidi Daoued fishing harbour

Exploitation date	1983
Geographical position	37°00 North and 10°54° East
Governorate	Nabeul
Type	Costal harbour
Dike	910 m
Quay	187 m of 2 m
Floating quay	400 m of 2 m
Fences	120 m

Situation of Sidi Daoued fishing harbour

Sidi Daoued is a fishing port and lies close to the northern tip of Cap Bon about ten kilometers from the city of El Haouaria (Figure 1). The place is famous for organizing the game of Tunny. If you are visiting Sidi Daoued in the months between April and July, you can enjoy the sport of fishing Tunny which is done in the most brutal way. There is also a canning factory on the harbour where the fishes

are processed.



Figure 1 General view of the fishing harbour of Sidi Daoued.

Repair of the pavement of the fishing harbour

Reinforcement of the pavement

The working surface of an open-air storage yard is designed according to the type of container equipment used. It could be either paved or simply gravel covered. Usually, heavy forklifts impose stricter requirement on road surfaces than do tractors or straddle carriers. The rolling zones of portainers on tires are usually reinforced. The guidelines indicate the need for a minimum thickness of bituminous surfacing of 18 cm to avoid reflective cracking. Bituminous surfacing is relatively inexpensive, but it can be damaged by corner casting in the container storage area. Geosynthetics, as applied to flexible pavement systems, have been widely used in recent years. Geosynthetics reinforcement is typically placed in the interface between the aggregate base course and the subgrade.^{2,3} The paving calculation was determined in accordance with the requirements of NF P11-213-1[4] taking into account the following conditions:

- I. The pavement shall have a minimum percentage of frames satisfying the condition of non-tensile fragility defined by the Eurocode in accordance with the requirements of NFEN1992-[5], with a minimum of 0.4 in each direction.
- II. The diameter of the reinforcement must be less than or equal to 1/15th of the thickness of the pavement.
- III. The maximum distance between frames must not exceed 2 times the thickness of the pavement.
- IV. If the thickness of the pavement is less than 16 cm, a single sheet placed at mid thickness is allowed.

The thickness of the reinforced concrete top layer is 150 to 450 mm, dependent on the traffic loadings, the climate, the concrete quality, the type of concrete pavement and the properties of the substructure materials. In our case, a 250 mm thick reinforced concrete pavement was used. Table 3 gives the quantity of steel required for the reinforcement of the pavement (Figure 2) (Figure 3).

Table 3 Reinforcement of the pavement

No	Position	Number of bars	Diameter	Unit length	Total length	unit weight	Total Weight
Joint			(mm)	(m)	(m)	(Kg/m)	(Kg)
1	Upper layers	20	10	12	240	0.616	147.84
1	Upper layers	61	10	3.9	237.9	0.616	146.546
1	Lower layers	20	10	12	240	0.616	147.84
1	Lower layers	61	10	3.9	237	0.616	146.546
2	Upper layers	20	10	12	240	0.616	147.84
2	Upper layers	20	10	1.38	27.6	0.616	17.002
2	Upper layers	64	10	3.9	249.6	0.616	153.754
2	Lower layers	20	10	12	240	0.616	147.84
2	Lower layers	20	10	1.38	27	0.616	17.002
2	Lower layers	64	10	3.9	249.6	0.616	153.754
Total mass of							1225.96
volume of concrete pouring (m ³)							25
Steel ratio (Kg/m ³)							49.04



Figure 2 Situation of the fishing harbour Sidi Daoued.

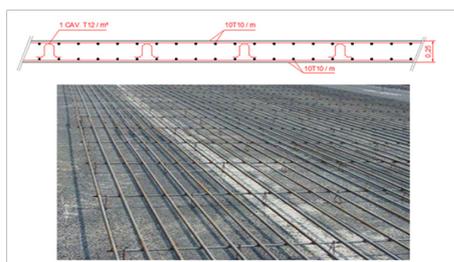


Figure 3 Reinforcement of pavement.

Joint in concrete pavement

The jointed reinforced concrete pavement is used in the following cases:

- I. A huge concentrated load are expected
- II. The designer has doubt about labor force who will build the concrete pavement.

Figure 4 shows the reinforcement of the expansion joint for the paving of the port of Sidi Daoued. A 2 cm thick expansion joint was created every length of 12m.^{6,7} The slab was divided into two parts, with a 50 cm wedge opposite to each side of the two steels in the second part of the pavement.

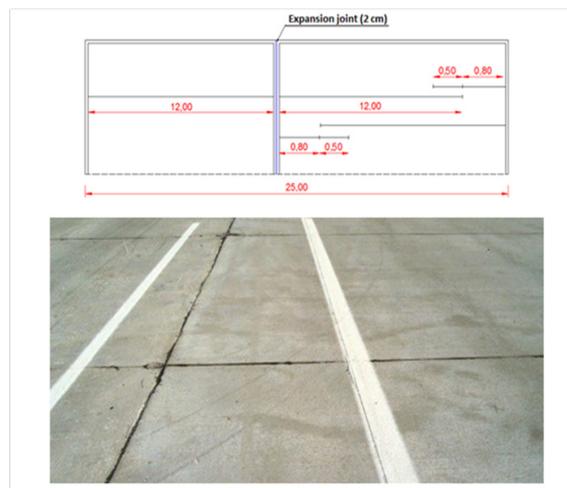


Figure 4 Jointed Reinforced Concrete Pavements.

The bollards of the fishing harbour

Bollard loads

The bollards shall be able to resist for ships of various tonnages. Table 4 gives the values of bollard load P and the approximate spacing between bollards. For larger ships, specific calculation must be carried out to determine the maximum bollard load, taking into account the type of ship and the environmental loading. If the berth structure is exposed a lot to wind and current, the above bollard loads should be increased by 25 per cent. When the ship is moored, the berth structure should be designed for a minimum vertical force of 0.87 times P. The bollard foundation itself should be designed for a force 20 per cent greater than the capacity of the bollard.

If harbour tugs are planned to escort large ships in fairways, i.e. to assist their transit at comparatively high speed, more attention is put on the indirect method of towing and the related hydrodynamic lateral

resistance force exerted on a tug’s hull in its oblique movement.^{8,9} Bollard loads are assumed to act in any direction within 180° around the bollard at the seaside, and from horizontally to 60° upwards, as shown in Figure 5.

Table 4 Bollard load P and approximate spacing

Bollard load P (KN)	Approximate spacing between bollards (m)	Bollard load normal from the berth (KN/m)	Bollard load along the berth (KN/m)
100	05-Oct	15	10
200	Oct-15	15	10
300	15	20	15
500	20	25	20
600	20	30	20
800	20 - 25	35	20
1000	25	40	25

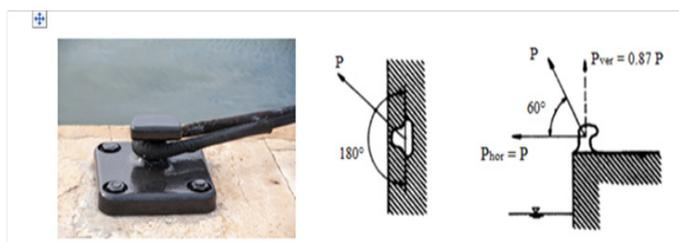


Figure 5 Bollard load directions.

Calculation of the bollard

For the calculation of the shear bollard, the dimensioning was carried out considering that the concrete has no shear resistance (critical hypothesis). The necessary section of steel A_s is given by:

$$A_s \geq \frac{1.25 \times P}{0.6 \times f_{bu}} \quad (1)$$

Where, P is the bollard load and f_{bu} is the ultimate shear stress of steel given by the following equation:

Table 5 Calculation assumptions for the study of the dock

Bollard load (KN)	Overloads (T/m ²)	Density of Block mates (T/m ³)	Concrete for mases	Concrete filling	Embankment mate	Rockfill materials
100	I	Reinforced concrete	Concrete for mases	Concrete filling	Embankment mate	Rockfill materials
		$\gamma = 2.5$	$\gamma = 2.4$	$\gamma = 2.2$	$\gamma = 1.8$	$\gamma = 1.8$
			$\gamma' = 1.4$	$\gamma' = 1.2$	$\gamma' = 1.1$	$\gamma' = 1.1$

$$f_{bu} = \frac{F_c}{\gamma_s} \quad (2)$$

Where, F_c is the elastic limit of high adhesion steel and γ_s is a coefficient

The following assumptions have been considered for the calculation of the bollard:

- I. The bollard load $P=100$ KN;
- II. $F_c=400$ MPa;
- III. $\gamma_s=1.15$

The results of calculations are shown schematically in Figure 6.

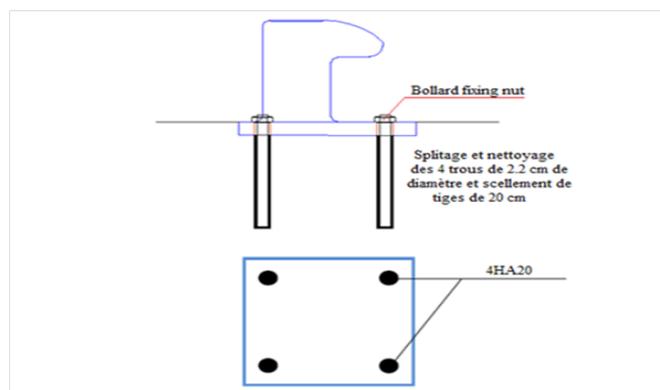


Figure 6 Bollard reinforcement with rods and nuts.

Study of the stability of the dock

The dock provides a direct link between the ship and the ground. He must resist:

- I. To the horizontal forces of docking and mooring and to the thrust of the embankments
- II. To the vertical forces due to its own weight, handling equipment and the loads on the median

It is therefore a question of checking the strength of the reinforced concrete sections of the coronation beam by the effects of the stresses of the ship and of the thrusts.

The calculation assumptions considered for the study of the stability of the dock are given in Table 5 The study of the stability of the dock was carried out by checking sliding and roll stability.

Sliding stability

This state is materialized by the balance of forces. Thus it becomes important to consider the possibility of dock moving on the foundation level. The horizontal forces tend to translate the dock wall and the sum of the vertical forces are opposed to this action. The sliding stability is given by the following equation:

$$\frac{\sum_{i=1}^n V_i}{\sum_{i=1}^n H_i} \geq 1.5 \quad (3)$$

Where, V_i is the sum of the vertical forces, H_i is the sum of the horizontal forces, 1.5 is the safety coefficient

Roll stability

The dock wall has been designed to resist the efforts that can cause it to overturn. In fact, the thrust of the earth and the lateral pressure due to overloads tend to tilt the wall by rotation.

The roll defined as the ratio between the stabilizing moment and the overturning moment as given by the following equation:

$$\frac{M_s}{M_o} \geq 1.5 \quad (4)$$

Where, M_s is the stabilizing moment, M_o is the overturning moment, 1.5 is the safety coefficient

Results of sliding and roll stability

Table 6 gives the results of sliding stability and roll stability for the different loading cases of the dock components. In the case number 1, the system formed by the charged capping beam (CB) is not stable ($1.20 \leq 1.5$ and $1.33 \leq 1.5$). For the case number 2, the system formed by the loaded capping beam (CB) and the block (B2) is stable since the values found are higher than the safety coefficient ($3.76 \geq 1.5$ and $2.24 \geq 1.5$). For the third case, the system formed by the charged capping beam (CB), the block (B2) and the block (B3) is always stable. For the latter case, we note that the system formed by the charged capping beam (CB) is always stable with the addition of block (B4). Indeed, according to the results shown in Table 6, we can note that it is necessary to build a retaining wall to ensure the stability of the dock. The following aspects were taken into account:

- I. The stability of soil around the wall;
- II. The stability of retaining wall itself;
- III. The structural strength of the wall;
- IV. The damage to adjacent structures due to wall construction.

The results of calculations are shown schematically in Figure 7.

Table 6 Sliding stability and roll stability for the different loading cases of the dock components

No	Schema of the loading Case	Sliding stability	Roll stability
1	<p style="text-align: center;">$Q = 1T/m^2$</p>	1.20	1.33
2	<p style="text-align: center;">$Q = 1T/m^2$</p>	3.76	2.24
3	<p style="text-align: center;">$Q = 1T/m^2$</p>	3.60	2.33

Table Continued

No	Schema of the loading Case	Sliding stability	Roll stability
4		5.97	3.51

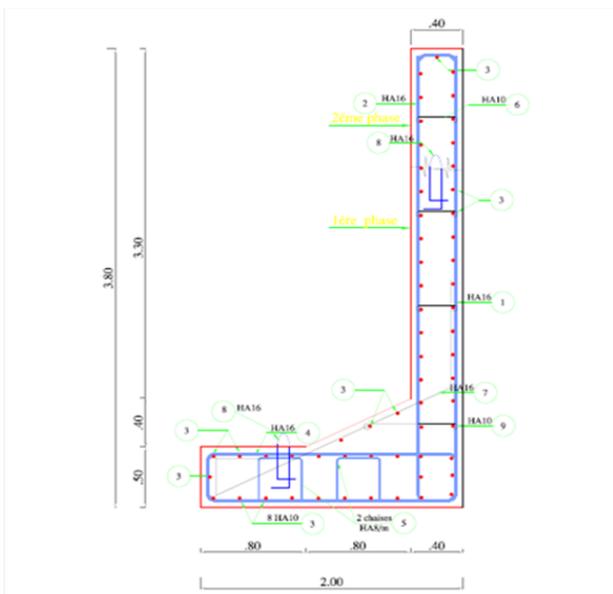


Figure 7 Reinforcement of the retaining wall.

Jacketing of the beams and columns of the auction hall

The conventional method, the effectiveness of which has been largely verified by experience, consists in jacketing the element by increasing its section by applying a thickness of concrete over the entire perimeter of the primitive element. The use of a self-compacting micro-concrete to fill the interstices without a vibration mode can be essential. The preparation of the support is very important, it is therefore necessary to make disbursements in the concrete to improve the transmission of forces, to treat the surfaces with a primary paint of epoxy resin.. Different researchers have employed various methods of jacketing for reinforced concrete (RC) elements.¹⁰⁻¹³ If reinforcement with reinforcements, it will be necessary to put this reinforcement in place and to carry out concreting by casting or pumping. When it is not possible to make a complete lining of the elements for the case of the facades, it is necessary to resort to other processes: reinforcement by metal plates or the thickening of the concrete element on two opposite faces.¹⁴ The reinforcing elements must be anchored in the

primitive concrete: either by bolting for the case of the metal plates, or by anchoring for the case of concrete additive. In our case the diagnosis of the auction hall which was built in 1975 showed that the concrete used for the columns and the beams was deteriorated. The measurement of the carbonation depth gave a minimum value of 5 cm with corrosion of the steels in the concrete. That is why we opted for jacketing of the columns and beams. The disadvantages of jacketing by the use of additional concrete are summarized in Figure 8.

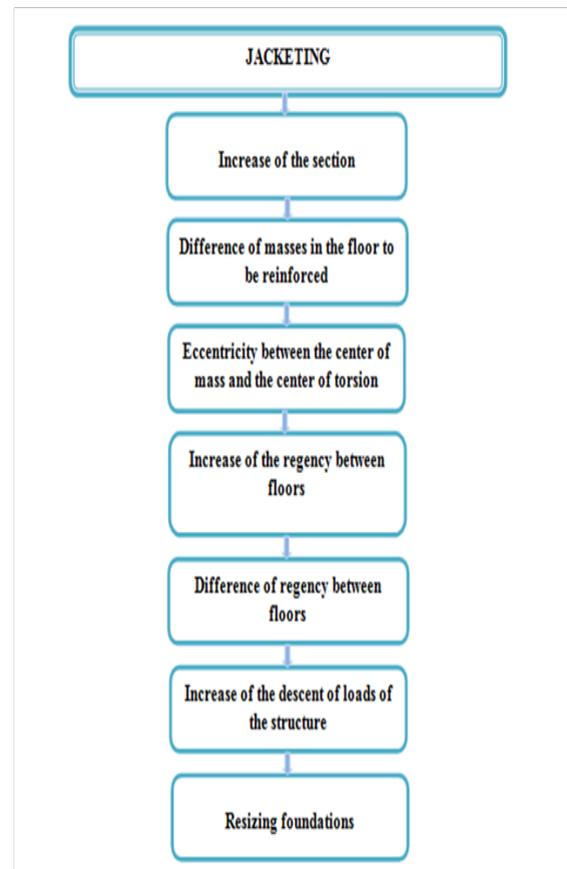


Figure 8 Disadvantages of jacketing by the use of additional concrete.

Column jacking

The reinforced concrete jacking results in an increase in the section of the column and this is done by adding the longitudinal and transverse reinforcements to the existing element and then the establishment of a new concrete coating. This technique is applied for poles to ensure the following needs:

- I. Increased lift
- II. Increased flexural and shear strength
- III. Increased deformation capacity

A preparation of the surface of the reinforced concrete element is required, for this a disbursement is necessary in the concrete for an improvement of the transmission of forces. The treatment of the surface is made with a primer layer of epoxy resin. If the reinforcement is with reinforcements, this leads to a setting up of the reinforcements then the realization of concreting by pouring or pumping is made. The calculation of the reinforced concrete was carried out according to the BAEL rules. The ultimate load, at the ground floor, has been halved since there are two L-shaped columns. The calculation was made using the Arch ® software as shown in Figure 9. The following assumptions have been considered for the calculation of columns: Concrete: RC28=25 MPa; Steel: Fee 400MPa. The results of calculations are shown schematically in Figure 10.

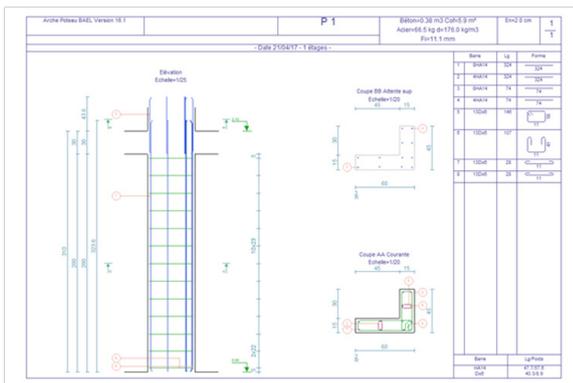


Figure 9 Calculating section column L using Arche ®software.

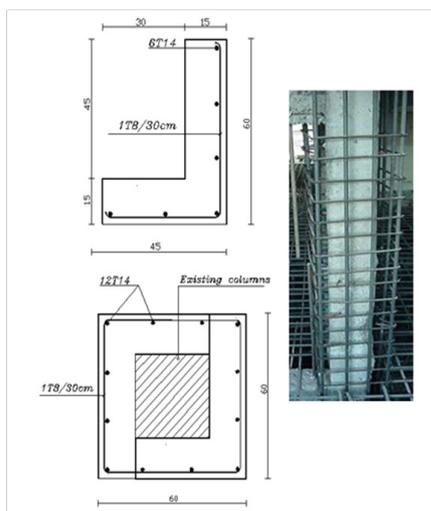


Figure 10 Construction Technique for Column Jacking.

Beams jacking

Jacking of beams is recommended for several purposes as it gives continuity to the columns and increases the strength and stiffness of the structure. The use of steel connectors is of extreme importance in the case of beams. Several publications,^{15,16} including codes and standards,^{17,18} deal with this subject. Before taking up the strengthening of a beam, the load acting on it should be reduced by removing the flooring tiles and bed mortar from the slab. Props are erected to support the slab. After clipping off the existing plaster on the beam, additional longitudinal bars at the bottom of the beam together with new stirrups are provided. Stirrups are inserted by making holes from the slab. The longitudinal bars are passed through the supporting columns through holes of appropriate diameter drilled in the columns. The spaces between bars and surrounding holes are filled with epoxy grout to ensure a good bond. These steps are illustrated in Figure 11. The surface of old concrete is cleaned by air jetting. Expanded wire mesh is fixed on the two sides and bottom of the beam. To ensure a good bond between old concrete and new polymer modified concrete, an epoxy bond coat is applied to the old concrete surface. The polymer modified mortar is applied, while the bond coat is still fresh. Sometimes 2 to 3 coats of polymer modified mortar are applied to achieve desired thickness. The mortar is cured for appropriate period in water. Epoxy resin grout is injected in the cracks along top of beams.

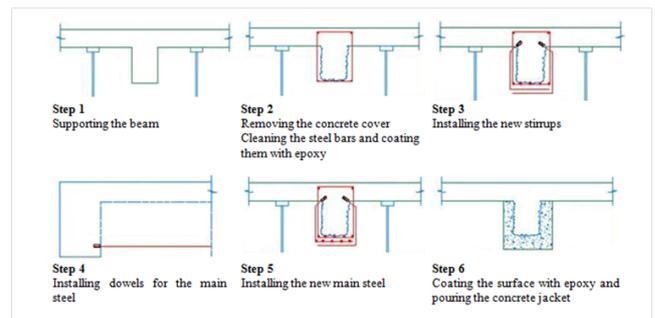


Figure 11 Construction Technique of beam jacking.

Table 7 gives the main features of reinforcement details of beam jacking.¹⁹ The beam is composed of three spans, it has a section of 30cm x 60cm. The calculation was made using the Arch® software. The results of calculations are shown schematically in Figure 12.

Table 7 Reinforcement details of beam jacking

Descriptions	Details
Minimum width for jacket longitudinal reinforcement	8 cm if concrete cast in place or 4 cm for shotcrete.
Shear reinforcement	Percentage of steel on the jacket should be limited to 50 of the total area of the composite section. Ignore the effect of existing shear reinforcement. New reinforcement should have 135 hooks and each corner of the tie there must be at least one longitudinal bar. The bar used for the tie should have at least 8 mm diameter. Multiple piece ties can be used, as discussed before for columns.

Table Continued

Descriptions	Details
Depth of jacketed beam	Span/depth ratio. Storey height, Ductile behavior

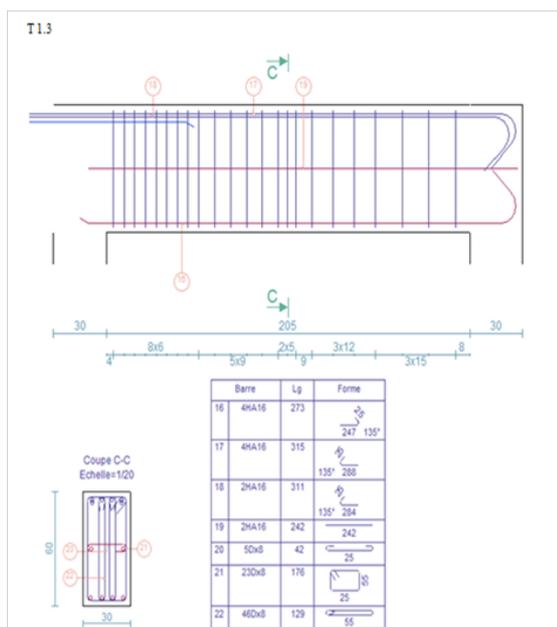
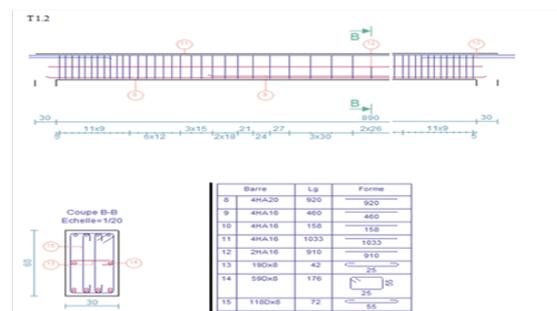
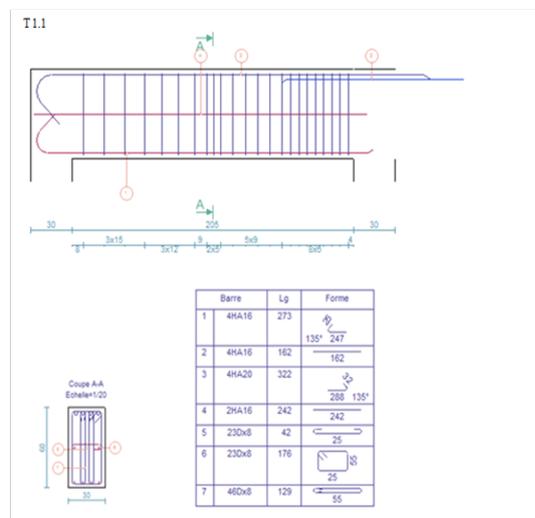


Figure 12 Reinforcement of the three spans of the beam using the Arch ® software.

Conclusion

- I. The present paper has presented results of an experimental study carried out in the fishing harbour of Sidi Daoued which is located close to the northern tip of Cap Bon. The test results were analyzed to identify the different disorders in the different elements of the fishing harbour. The following conclusions have been drawn from the investigation:
- II. The visual inspection of the state of the structure was performed to quickly assess the damage and determine the appropriate way of expedient examinations.
- III. A reinforced concrete pavement of 25 cm thickness was used with a steel ratio of 50Kg/m³. An expansion joint was created every length of 12m so that the two concrete surfaces are free to move away from one another due to shrinkage or thermal movement.
- IV. A rods and nuts system has been proposed to ensure the resistance of the bollard for ships of various tonnages. The necessary section of steel was calculated ($A_s=12.6 \text{ cm}^2$) and an epoxy adhesive for reinforcement sealing was used (SIKADUR 30 glue).
- V. The values of the sliding stability and roll stability for the different loading cases of the dock components are lower than the safety coefficient (≤ 1.5). A reinforced concrete retaining wall was built to ensure the stability of the dock.
- VI. The jacketing techniques was used to improve the mechanical characteristics of the beams and columns of the auction hall in order to provide better strength serviceable and ultimate resistance state
- VII. The calculation of the reinforced concrete was carried out according to the BAEL rules. The calculation of the steel quantity for the jacketing of the beams and columns was made using the Arch® software.

Acknowledgments

None.

Conflict of interest

The author declares there is no conflict of interest.

References

1. Sciortino JA. Fishing harbour planning, construction and management. *FAO Fisheries and Aquaculture Technical Paper No 539*. 2010;337.
2. Barksdale RD, Brown SF, Chan F. Potentiel benefits of geosynthetics in flexible pavements systems. *National Cooperative Highway Research Program Report*; 1989.
3. Gregory GH, Bang S. Design of flexible pavement subgrades with geosynthetics. *Proc of 30th Sym Eng. Geology and Geotechnical Eng.* 1994;569–582.
4. Paving design, calculation and production part 1 contract bill of technical clauses for paving for industrial or related use. 2005.
5. Design of concrete structures. General rules and rules for buildings.
6. Joints in Concrete Construction. American Concrete Institute. État-Unis. 2001.
7. Guide for Concrete Floor and Slab Construction. American Concrete Institute. État-Unis. 1996.
8. Hensen H. Tug Use in Port (A Practical Guide). The Nautical Institute, London; 2003.

9. Allan RG. Tugs and Towboats. Ship Design and Construction. Jersey City; 2003.
10. Konstantinos G, Vadoros, Stephanos E, et al. Concrete jacket construction detail effectiveness when strengthening RC columns. *Construction and building material*. 2008;22(3):264–276.
11. Julio ES, Branco F, Silva VD. Structural rehabilitation of columns with reinforced concrete jacketing. *Progress in Structure engineering and materials banner*. 2003;5(1):29–37.
12. Ersoy U, Tankut AT, Suleiman R. Behaviour of jacked columns. *International Concrete Abstracts Portal*. 1993;90(3):288–293.
13. Rodriguez M, Park R. Seismic load tests on reinforced concrete columns strengthened by jacketing. *International Concrete Abstracts Portal*. 1994;91(2):150–159.
14. Cheong HK, Mac Alavey N. Experimental behavior of jacketed reinforced concrete beams. *ASCE Journal of Structural Engineering*. 2000;6(6):692–699.
15. Kaar PH, Kriz LB, Hognestad E. Precast–prestressed concrete bridges(1). Pilot Tests of continuous girders. *Journal of PCA Research and Development Laboratories*. 1960;2(2):21–37.
16. Loov RE, Patnaik AK. Horizontal shear strength of composite concrete beams with a rough interface. *PCI Journal*. 1994;39(1):48–109.
17. Manual of concrete practice, Part 3: Use of Concrete in Buildings Design, Specifications and Related Topics. 1996.
18. Design of Concrete Structures. Part 1-3: General Rules- Precast Concrete Elements and Structures CEN. 1994.
19. Shri Pravin B. Waghmare. Materials and jacketing technique for retrofitting of structures. *International Journal of Advanced Engineering Research and Studies*. 2011;1(1):15–19.