A harbor is a facility for receiving ships and transferring cargo. They are usually situated at the edge of an ocean, sea, river, or lake. Ports often have cargo handling equipment such as cranes (operated by longshoremen) and forklifts for use in loading/unloading of ships, which may be provided by private interests or public bodies. Often, canneries or other processing facilities will be located nearby. Harbor pilots and tugboats are often used to maneuver large ships in tight quarters as they approach and leave the docks.

Several recent studies have produced a considerable body of work related to the fishing harbors (Ben-Yami 1985; Pollnac 1994; Pomeroy 1994; Singh and Ham 1995). In fact, fishing harbor provides dedicated port and supporting infrastructure facilities required by the fishing and fish processing industries, for:

1. the safe berthing of fishing vessels, where the vessels can discharge their catches, take on bunker, water, ice and other necessary provisions, and berth for idle times and repairs;
2. the use of public utilities by provision of networks for distribution to port customers of electricity, water, as well as environmental protection facilities required for garbage collection and disposal, wastewater and sewage discharge and treatment, and oil reception from vessels;
3. the development of fish processing industries and markets and related highest hygienic standards by provision of land areas and optimized land use planning, including transportation and communication facilities.

The role of the fishing harbor may be considered as the interface between the netting of fish and its consumption. In many cases, the fishing harbor is also the focal point of pollution, both of the surrounding environment and the fishery products it produces. Many fishing harbors are also the source of major impacts on the physical and biological coastal environment (Sciortino 2010).

A fishing harbor should serve as an integrated fish industry with operational facilities, provision of repair and maintenance services for the fishing fleet and fish storage, and processing and sales activities. Consequently, the fishing port complex is subject to multipurpose use involving all functions and services directly and indirectly connected with the fishing and fish industry.

In today’s world of increased environmental awareness, a fishing harbor must be planned, designed and managed in harmony with both the physical and biological coastal environments. At each stage of the process, whether it is planning, design or management, both technical and non-technical persons become involved in the process. Within government departments, whether they be technical (fisheries or public works) or non-technical (budget or finance), it is not uncommon for non-technical persons to affect the outcome of technical decisions. Fisheries departments worldwide generally have to manage and maintain harbors and landing places using non-engineering civil servants.

The present paper presents the results of an experimental study carried out in the fishing harbor of Sidi Mansour. The manufacturing of a 361.5-meter-long dock was made from three types of reinforced concrete blocks. A compression test
machine and a slump test were used to determine respectively the compressive strength of cylindrical concrete specimens at the ages of 4,7 and 28 days and the workability of fresh concrete.

2 HARBOR DOCK

The harbor dock is a structure of embarkation or landing of sinners which ensures the ship/land connection. It supports the lands at the limit of the water and provides the support device. The support function of the ship is always ensured by the structure, the mooring can be carried out on separate points, the connection with the land is ensured either by the work or by the platform directly behind him. Land support can be provided either by the structure or by an ancillary work (embankment slope).

For safety, the required overage compressive strength at 28 days represents an increase of 6 MPa of the desired resistance. So the required overage compressive strength is calculated using the equation (2):

$$\sigma'_{28} = \sigma_c + 6$$

(2)

From equation (1), the report C/W can be calculated using the equation (3):

$$\frac{C}{W} = \frac{\sigma'_{28}}{G\sigma_c} + 0.5 = \frac{40 + 6}{0.6 \times 45} = 2.2$$

(3)

we note from equation (3) that the cement content increases when the required overage compressive strength of the concrete is high. Conversely, the cement content decreases as the strength of the concrete increases. For a required overage compressive strength, there is also less need for cement when the quality or size of aggregates increase.

Table 1. Physical and mechanical properties of cement

<table>
<thead>
<tr>
<th>Properties</th>
<th>Absolute density (g/cm$^3$)</th>
<th>Bulk density (g/cm$^3$)</th>
<th>Blaine specific surface (cm$^2$/g)</th>
<th>True class of strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>3.10</td>
<td>1.05</td>
<td>3100</td>
<td>45</td>
</tr>
</tbody>
</table>

Natural sand 0/4 was used as fine aggregates. Gravel 4/12 and gravel 12/20 were used as coarse aggregates. Particles size distribution of sand and gravel was determined by the classical method of sieving described in the standard NF EN 933-1(NF EN 933-1 2012). The physical characteristics of the aggregates used in the preparation of concrete mix are shown in Table 2.

Table 2. Physical characteristics of aggregates

<table>
<thead>
<tr>
<th>Aggregates</th>
<th>Absolute density (g/cm$^3$)</th>
<th>Bulk density (g/cm$^3$)</th>
<th>Finesse modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand 0/4</td>
<td>2.45</td>
<td>1.62</td>
<td>2.53</td>
</tr>
<tr>
<td>Gravel 4/12</td>
<td>2.60</td>
<td>1.60</td>
<td>-</td>
</tr>
<tr>
<td>Gravel 12/20</td>
<td>2.60</td>
<td>1.60</td>
<td>-</td>
</tr>
</tbody>
</table>

3.2 Cement and Water Content

The dosage of water and cement depends on the target resistance, and the quality of the cement and aggregates. The cement/water ratio (C/W) is approximately evaluated using the overage compressive strength $\sigma'_{28}$ and the required plasticity using the equation (1):

$$\sigma'_{28} = G\sigma_c \left( \frac{C}{W} - 0.5 \right)$$

(1)

where $\sigma'_{28}$ is the required overage compressive strength at 28 days in MPa; $\sigma_c$ is the true cement class at 28 days in MPa; C is the cement content in Kg/m$^3$; W is the total water content in Kg/m$^3$; G is the granular coefficient which represents the aggregates quality.

Table 3 gives the values of granular coefficient G according to the aggregates quality and dimensions. It is concluded that the granular coefficient G is equal to 0.6 since the dimensions of the aggregates used for the manufacture of concrete are between 25mm and 40mm.

Table 3. Values of granular coefficient G

<table>
<thead>
<tr>
<th>Aggregates quality</th>
<th>D $\leq$ 16mm</th>
<th>25 mm $\leq$ D $\leq$ 40 mm</th>
<th>D $\geq$ 63mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>0.55</td>
<td>0.60</td>
<td>0.65</td>
</tr>
<tr>
<td>Good</td>
<td>0.45</td>
<td>0.50</td>
<td>0.55</td>
</tr>
<tr>
<td>Fairly good</td>
<td>0.35</td>
<td>0.40</td>
<td>0.45</td>
</tr>
</tbody>
</table>

In the case of a prefabricated reinforced concrete block dock (case of our project), the dock wall was consisted of prefabricated concrete blocks, hollowed out or not, stacked under the water on top of each other, above a well-adjusted seat. The empty blocks were filled with embankment, and the whole was joined together by a reinforced concrete coping beam cast in situ above the level water level after backfill placement.

3 PREPARATION OF CONCRETE MIX: DREUX-GORISSE METHOD

3.1 Materials

The cement used was a CEM I 42.5, in conformity with the Standard NF EN 197-1 (NF EN 197-1 2012), produced by the Cement Company of GABES. The physical and mechanical characteristics of cement are shown in Table 1.

According to the value of the Cement/Water ratio (C/W), the overage compressive strength at 28 days represents an increase of 6 MPa of the desired resistance. The dosage of water and cement depends on the target resistance, and the quality of the cement and aggregates. The cement/water ratio (C/W) is approximately evaluated using the equation (2):

$$\frac{C}{W} = \frac{\sigma'_{28}}{G\sigma_c} + 0.5$$

(2)
Figure 1. Cement content to use in respect to the required C/W ratio and the workability

3.3 Aggregates Content

The granular reference curve OAB was drawn on the same graph as the granulometric curves of the components aggregates (Figure 2). The point B is placed at 100% and it corresponds to the dimension D of the greatest aggregate and the point O is placed at 0%. The abscissa and the ordinate of the breaking point A are defined by the equation (5) and (6):

\[ X_A = \frac{D}{2} \quad (for \ D \leq 20) \]  
\[ Y_A = 50 - \sqrt{D} + K + K_S + K_P \]  

where K is a corrective term which depends on the cement content, the clamping effectiveness, the rolled or crushed aggregates shape and also on the sand fineness modulus.

If the sand finesse module FM is strong (coarse sand), an additional correction \( K_S \) will be made to raise the point A as defined by the equation (7):

\[ K_S = 6FM - 15 \]  

If the quality of the concrete is to be specified pumpable, it will be advisable to confer on the concrete the maximum of plasticity and to enrich it in sand compared to a concrete of current quality. It will be possible for this to increase the corrective term K of the value \( K_P = +5 \) to +10 according to the desired degree of plasticity.

By replacing the terms of equations (5) and (6) by their values, we find:

\[ \begin{cases} X_A = \frac{D}{2} = 20/2 \\ Y_A = 50 - \sqrt{20} - 4 + 0.18 \end{cases} \Rightarrow \begin{cases} X_A = 10 \\ Y_A = 41.7 \end{cases} \]

Once the granular reference curve OAB has been drawn, the dividing lines between each aggregates type were traced by joining the point at 95% of the granular curve of the first aggregates type to the point at 5% of the granular curve of the following aggregates type and so on. According to Figure 2, the percentage of sand and the two types of gravel are respectively \( g_1 = 36\% \), \( g_2 = 20\% \) and \( g_3 = 44\% \).

The cement grains net volume is given by the equation (8):

\[ c = \frac{C}{\rho_C} \]  

where \( \rho_C \) is the cement grains specific mass equal to 3.100 and C is the cement dosage equal to 400.

The net volume of all the aggregates is given by the equation (9):

\[ V = 1000\gamma - c \]  

where \( \gamma \) is the compactness coefficient depends on the type of vibration, the consistency of the mix and the maximum diameter of the aggregates.

The net volumes of each aggregates are then given using the equation (10):

\[ \begin{cases} v_1 \geq g_1 V \\ v_2 \geq g_2 V \\ v_3 \geq g_3 V \end{cases} \]  

To get the mass of each aggregate, the net volumes have been multiplied by the specific masses of each of this aggregate. Table 4 gives the mass of each aggregate used for making a cubic meter of concrete.

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Percentage of aggregate</th>
<th>Compactness coefficient</th>
<th>Cement grains net volume (L/m³)</th>
<th>Net volume of aggregates (L/m³)</th>
<th>Net volume of each aggregate (L/m³)</th>
<th>Mass of each aggregate (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>36%</td>
<td>0.815</td>
<td>129</td>
<td>680</td>
<td>137</td>
<td>357</td>
</tr>
<tr>
<td>Gravel 1</td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel 2</td>
<td>44%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4 Preparation of dock blocks

The types and dimensions of blocks realized in this project are presented in Table 5. The pouring of each block was completed without interruption. All the precautions were taken (watering on concreting area) to prevent the concrete from drying out during the first days of hardening. The particle size composition approved by the engineer has been respected to allow, from the dosages and qualities of imposed cement, to obtain the required minimum strengths.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Dimension (m)</th>
<th>Volume (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>250</td>
<td>3.200 × 1.500 × 1.000</td>
<td>4.800</td>
</tr>
<tr>
<td>B</td>
<td>250</td>
<td>2.650 × 1.500 × 1.000</td>
<td>3.975</td>
</tr>
<tr>
<td>C</td>
<td>250</td>
<td>2.100 × 1.500 × 1.000</td>
<td>3.150</td>
</tr>
</tbody>
</table>

Well cared metal forms were used to ensure the formwork of the different blocks (Figure 3). The surfaces of the sheets in contact with the concrete do not have mesh and meet the flatness conditions normally accepted for the locksmith structures.

The formwork preparation was carried out according to the following steps (Figure 4):

1. The forms were carefully cleaned to remove stains from the hydrocarbon products (grease) and remove traces of rust.
2. Immediately prior to concrete placement, the forms were carefully brushed to remove dust and debris of all kinds.
3. A layer of oil has been applied to the internal surfaces of the formwork in order to facilitate the operation of blocks demolding.
4. Clean the platform of all elements that can act on the lower surface of the block before putting the formwork in place.
5. The formwork was moved to the intended pouring location using a loader. A polyethylene film has been placed under the formwork to facilitate the handling of the hardened block.

3.5 Pouring Concrete

The concrete pouring of each block was completed without interruption. All precautions have been taken to ensure (day by day) the watering on concrete area to prevent drying out of the concrete during the first days of curing.

A ready mixed concrete was used for pouring blocks as shown in Figure 5. The vibration was provided by electric concrete vibrator with needle flexible shaft. The vibrator needle was immersed vertically or at a low angle, then slowly back up. The successive vibration points should not be too close to the formwork. The surfaces were treated using a ruler and a trowel to provide a flat and smooth surface.

After twenty-four hours, formworks can be safely removed. On each block, a number and the date of its manufacture was noted. After 7 days of pouring, the blocks were transported to the storage area using a loader.
4 CONCRETE TESTS

4.1 Compressive Strength Test

A sample collection of concrete was performed compulsorily for each pouring of 50 m$^3$ or at the request of the representative of the administration. The molds of the cylindrical concrete specimens collected (Figure 6) were crushed in laboratories by three samples at the ages of 4 days, 7 days and 28 days to control the resistance of cast concrete on site.

Figure 6. Cylindrical concrete specimens 16 cm × 32 cm

The compressive strength of specimens was determined by destructive testing with a compression test machine according to the requirements of NF EN 12390-3 (NF EN 12390-3 2009). Progressive loading with a rate of 0.5 MPa/s was applied to the crushing of the specimen. The compressive strength value was read directly from the computer screen (Figure 7).

Figure 7. Compression strength test

According to the results shown in Table 6, it is noted that the average compressive strength of the specimens is equal to 12.50 MPa at the age of 4 days, 25.000 MPa at the age of 7 days and 35.100 MPa at the age of 28 days. we also note that the concrete can reach 50% of its compressive strength at the age of 4 days, which allowed us to transport the blocks after 7 days of pouring the concrete. At the age of 28 days, the value of the compressive strength is even greater than the minimum resistance required (35.100 MPa > 30.000 MPa).

Table 6. Compressive strength of specimens at the ages of 4, 7 and 28 days

<table>
<thead>
<tr>
<th>Age of specimen</th>
<th>Specimen</th>
<th>Density (g/cm$^3$)</th>
<th>Maximum load (kg)</th>
<th>Compressive strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 days</td>
<td>C1</td>
<td>2.47</td>
<td>36700</td>
<td>18.350</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>2.46</td>
<td>36200</td>
<td>18.100</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>2.46</td>
<td>39000</td>
<td>19.500</td>
</tr>
<tr>
<td>7 days</td>
<td>C1</td>
<td>2.38</td>
<td>43400</td>
<td>21.700</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>2.40</td>
<td>51000</td>
<td>25.500</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>2.41</td>
<td>54600</td>
<td>27.300</td>
</tr>
<tr>
<td>28 days</td>
<td>C1</td>
<td>2.39</td>
<td>72100</td>
<td>36.050</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>2.43</td>
<td>70700</td>
<td>35.350</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>2.41</td>
<td>67800</td>
<td>33.900</td>
</tr>
</tbody>
</table>

4.2 Slump Test

Concrete slump test is an on-the-spot test to determine the consistency as well as workability of fresh concrete. This test plays a vital role in ensuring immediate concrete quality in a construction project. It is used almost in every construction sites.

Slump test is very simple and easy to handle. It also demands comparatively less equipment and can be done in a short period of time. These advantages of slump test have made it very popular all over the world. In slump test, workability of concrete is not measured directly. Instead, consistency of concrete is measured which gives a general idea about the workability condition of concrete mix.

Concrete slump test was determined according to the requirements of NF EN 12350-2 (BS EN 12350-2 2009) in the following steps (Figure 8):

1. Cleaned carefully the internal surface of the mould and applied an oil on the surface.
2. Filled the mould with fresh concrete in three layers. A steel rod with diameter of 16 mm was used to tamp each layer. The rod is rounded at the ends and the tamping should be done uniformly. Removed excess concrete after filling the mold with fresh concrete.
3. Lifted gently the mould in the vertical direction and then unsupported concrete will slump.
4. Measured the slump of the concrete by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.

According to the measurement result, we note that the workability of fresh concrete is medium (slump value 50 mm -90 mm). Indeed, the mixes are typically used for normal reinforced concrete placed with vibration.
5 CONCLUSION

The present paper has presented results of an experimental study carried out in the fishing harbor of Sidi Mansour located 12 km north-east of Sfax, on a broad promontory forming a protuberance in relation to the general orientation of the coast. The following conclusions have been drawn from the investigation.

1. The Dreux-Gorisse method was used to determine the cement and aggregates content for the concrete mix.
2. The values of cement and water content for the concrete mix are respectively $C = 400 \text{ kg/m}^3 + \text{liquifier}$ and $W = 182l$.
3. The masses of the different aggregates were determined by the Dreux-Gorisse method.
4. The manufacturing of the harbor dock needs three types of reinforced concrete blocks A, B and C of volumes respectively $4.800 \text{ m}^3$, $3.975 \text{ m}^3$ and $3.150 \text{ m}^3$.
5. The values of compressive strength of cylindrical concrete specimens ($16 \text{ cm} \times 32 \text{ cm}$) at the ages of 4, 7 and 28 days are in accordance with the specifications of the project.
6. The workability of fresh concrete were identified using a slump test. The slump value is equal to 58 mm. The results reveal that workability is medium (slump value 50 mm~90 mm) and the mixes are typically used for normal reinforced concrete placed with vibration.

ACKNOWLEDGMENTS

The authors express our thanks and gratitude for all who helped us to prepare this study, especially the Agency of the Harbors and Fishing Facilities (APIP) and the civil engineering department of the higher institute of the technological studies of Sfax for their assistance and contribution to the development of this work.

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