ADVANCED SYSTEM FOR VISUALISING PLACEMENT OF ARMOUR UNITS UNDERWATER

Mr. Michel Denechere[1] and Mr. Michel Fons[2]

The positive and required interlocking of armour units is always difficult to achieve, and ensure, especially in poor or variable underwater visibility conditions. The POSIBLOC™ system was invented and developed to enable the placing crane driver to visualise, in realtime, the position and attitude of each unit in complete safety and in any water visibility conditions. The system is considered to be a very effective way of achieving and ensuring dedicated accurate placement control of the units as they are incorporated in the "Works".

1 -INTRODUCTION

The placement of concrete armour units requires time and attention to detail, especially as interlocking of adjacent units is fundamental in achieving structural stability and if the design criteria of the armour layer is to be correctly implemented as specified by the designer and the creator/developer of the technology.

The achievement of the of high interlocking capabilities of armour units, such as the units used in single layer systems, must comply with the placement criteria such as the grid dimensions, packing density etc if the full potential interlocking capabilities are to be achieved, as illustrated in Fig.1.

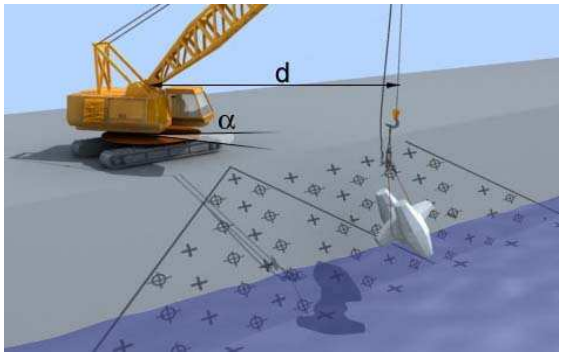

Figure 1. Placement principle of the single layer armour

[1] Managing Director, Concrete Layer Innovations (CLI), Tours, France, michel.denechere@concretelayer.com
[2] Project Director, Sogreah Consultants, Echirolles, France, michel.fons@sogreah.fr

When placing units above water, these specification and criteria requirements are readily achievable as the units are clearly visible at all times. When the placement of units is required under water however, the crane driver and the placing crew must rely on feedback from divers in order to achieve the interlocking and placement accuracy required. This operation is both time consuming and, more importantly, potentially hazardous in adverse weather conditions – even more so when the units are required to be placed in deep water as visibility is usually poor and may also be restricted by tidal currents. Defects in placement are not always recognised at the time and dismantling of a section of armouring may be required as a consequence which is inevitably time consuming and expensive.

In order to reduce and potentially eliminate the risk of major placing defects underwater, it was recognised that new systems and instrumentation together with specific software were required to show the placing crane operators the exact location and orientation of the units during all phases of armour placement.

Placing from a barge mounted crane makes DGPS information potentially unreliable and misleading. Furthermore the use of divers in adverse waves and currents is unsafe. As a result, the professional engineering and diving community expressed the need for a system and the tools for placing single layer units underwater accurately in such adverse conditions.

The technology presented in this paper, "POSIBLOC™", is a system using sensors capable of accurately portraying the position and attitude of each armour unit as it is placed in any configuration in states of poor water visibility. These requirements for such an alternative solution for placing armour units are satisfied if the following intended objectives are met:

1. In any water visibility conditions precise location at all times. This information will be better than with divers' assistance.
2. In any water visibility conditions, measurement of the attitude of the unit being placed. Again, that information will be better than with divers' assistance.
3. Positions and attitudes of already placed units will be recorded and displayed.
4. Real-time display of all armour units with choice of tools for easy visualization

The system mounted on a crane is shown hereafter:

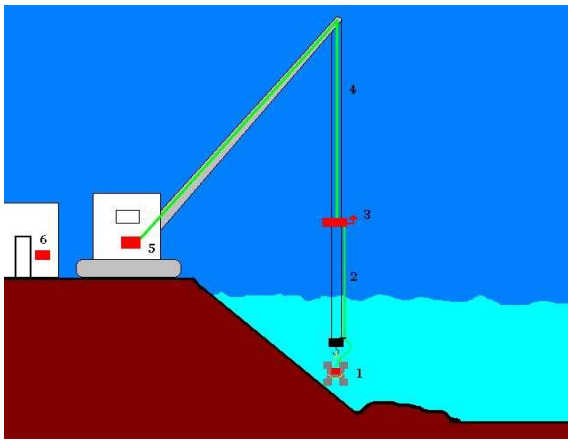

Figure 2. POSIBLOC™ schematic
1. Removable measurement box on unit, 2. Power cable (downwards), 3. RTK GPS positioning system along the cable (X1, Y1, Z1), 4. Power cable (upwards), 5. Cabin Display (VISIBLOC™ under QINSY OS), 6. Site manager computer with VISIBLOC™ software.

2- BASIC PRINCIPLE OF THE POSIBLOC™ System

In order to improve the quality and safety during placing operations of armour units, the system proposed is to install instrumentation and a detachable instrumentation box on each armour unit, to relay the information as to the unit's actual location to a computer and software together with a visual display in the crane driver's cabin.

The functions of the various components are as follows:

- The removable orientation sensor located on the concrete unit recognises the attitude of the unit being placed by a crane (See Fig. 3).
- The positioning frame suspended along the cables locates accurately the centroïd of the unit in space.

Both measurements, together with the data processing computer, allow the unit being placed to be displayed on a screen.

The positioning frame includes one GPS-RTK system (See Fig. 4). Distances to the concrete unit are accurately measured by distance measurement devices, which are of the incremental type. All systems are self-operational without calibration.

Figure 3. Measurement box on a CORELOC™ unit

Figure 4. Cable drum measuring frame

This arrangement enables the crane driver to “see” (Refer to Fig; 5 & 6) the unit being placed underwater in 3D and to present the unit in relation to the units already positioned.

Figure 5. POSIBLOC Illustration

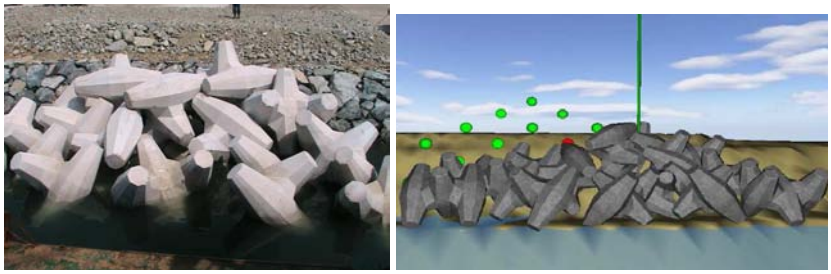

Figure 6. Graphical representation on the right vs. actual configuration on the left

Current practice when placing units is for the crane to be fitted with a GPS RTK system that gives a highly accurate position of the GPS antenna at the jib head only. The actual centre of gravity of the unit is not known.

The POSIBLOC™ system includes inclinometers, cable drum measuring frame and compass on the cable. With these measurements, the system corrects the GPS position X1, Y1, Z1 and gives the position of the centre of gravity of the unit in X2, Y2, Z2.

The armour unit position X2, Y2, Z2, is obtained in real time and its orientation is recognised by the measurement box located on the unit and relayed to the computer/screen.

Before the placing commences, the software must be formatted for the local conditions i.e. Geographical area for the GPS, local system of co-ordinates, incorporation of a base map file of the terrain (See Fig. 7) and showing the existing underlayer profile definitions and/or choice of unit geometry.

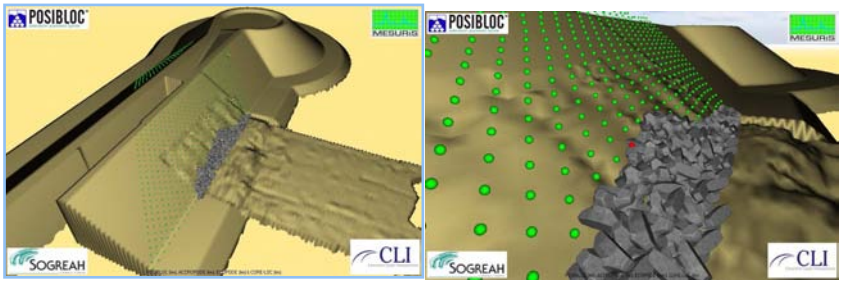

Figure 7. Representation of the surveyed underlayer (limited stretch shown)

At the commencement of placing, using the POSIBLOC™ system, the crane driver is required to carry out the following repeating procedure:

1. Place the sensor on the unit prior to slinging the unit and enter the details for QA/QC.
2. Move the armour unit to the theoretical target. Use x, y co-ordinates and guidance.

3. Lower the unit underwater into position. On the screen, adjust visually the unit to a best fit attitude and position.
4. Record the position and co-ordinates of the placed unit in the computer.
5. "Pull" the measurement box free from the unit and return to unit handling crew.

The prime requirement is that the control of the units positioning including set up of the systems and recovery should be operational at all times (24 hours if necessary) and would only require minimum use of divers. Using the system, greater placing daily rates can be achieved.

3- SCREEN DISPLAY USING VISIBLOC SOFTWARE

When the software and sensors are activated, the positioning system defines the position and orientation of each unit in real time and displays it on the screen. The crane operator is able to choose the graphical representation that he wishes to use: 2D view with multiple windows and points of view: bird's eye view, view parallel or perpendicular to the crane centre line or a 3D perspective view, with the possibility to zoom on each window.

The VISIBLOC™ software has been developed such that the geo-referenced position and orientation of each unit is recorded to provide 'as-built' placement drawings, as well as actual packing densities. Information documentation available from the system is equally as good as and more often better than underwater photographs and is precise in its location.

The accuracy of the system as illustrated in Fig. 8 is maximum 15 cm or H/12 (H being the unit height), whichever is the least.

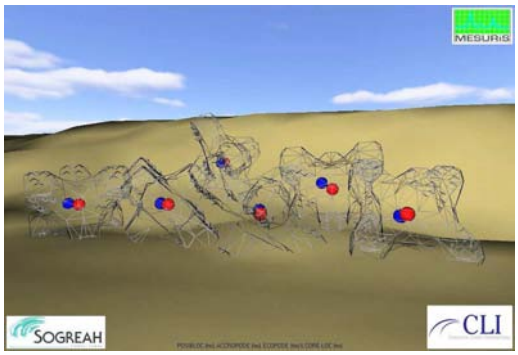

Figure 8. Positioning accuracy (actual vs represented centroïds)

Additional information from the POSIBLOC™ system allows measuring the attitude of the units for displaying it on a screen together with the attitude of the other adjacent units (See Fig. 9 & 10). This is the fundamental information which indicates whether or not the correct placement of the units has been achieved.

Improvements of the system will be developed, one of them to suggest several 3D solutions in presenting the armour unit in position in order to find the optimum orientation/ interlocking according to the units already positioned.

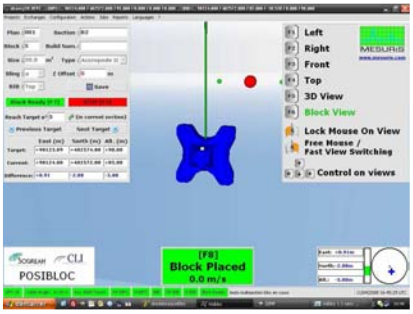

Figure 9. Display functions in crane cabin

Figure 10. Underwater placement of first row of units

Experience has been gained from the two first POSIBLOC™ applications, and the system is undergoing further improvements:

- Detachable measurement box retrieval sling is modified to operate without the various wires becoming entangled.
- More accurate measurements and recording tools are to be commissioned and developed, especially under dynamic condition (offshore placement)
- The detachable measuring box has been miniatured, as shown in Fig. 11, and is thus less prone to being crushed or damaged on final approach.

Figure 11. Size evolution of the measuring box

4- CONCLUSION

The current system of unit placement using GPS on the jib head of the crane is only as good as the clarity and calmness of the water allows. Even at shallow depths, the current system requires the use of divers to ensure correct placing and interlocking of the armour units underwater. If however it is not used with the proper assistance of divers, the positions and interlocking of the units cannot be checked. It was therefore considered essential to develop a system with real time visual aid to allow the project staff to monitor and record placement of armour units underwater on an ongoing basis. The POSIBLOC™ system together with specific computer software has been developed to position each unit in real time. Prior to lifting, the armour is instrumented with detachable sensors which allow virtual reproduction on the computer monitor of the exact shape and attitude of the unit being placed, thus allowing correct interlocking with units placed (pre-recorded attitudes). The POSIBLOC™ system allows the measurement of the centroïd of the armour unit with sufficient accuracy to guarantee that each unit is placed between two other ones of the rows just below and at a correct position compared to the general alignment of the armour layer. If the units are placed with a correct random slinging and given the correct and effective interlocking the units this information is already sufficient for ensuring the correct placement of the units. Random inspection by divers may be considered but the risk of incorrect placement is low.

Summarizing, the main advantages of the POSIBLOC™ are as follows:

- Reproduces the armour configurations with actual unit geometry.
- Can operate 24 hours a day and is not limited by water visibility.
- Reduces the need of divers. Echo sounding devices can also be used as independent control tools.
- Eliminates potentially hazardous situations for divers and placing crew.
- Increases placement output.
- Enables the quality of interlocking between units to be visualized.
- Rapid ongoing control of unit placement and reduced risk of unit reworking.

This development is aimed at fulfilling a need in any water visibility conditions for the rapid and effective construction of the armour layers built with CLI single layer units is now available to all contractors.
Finally, it must be recognized that this system is an aid/tool for assisting the contractor in positioning the armour units, but it should not be considered as a substitute for effective and dedicated ongoing control of the works.

REFERENCES

CLI Technical specifications (2007), Placing of armour units.

Denechere and Thomson (1999). Experience with single layer breakwater amour, *Proceedings of COPEDEC 1999, Cape Town, RSA.*

Werren, Baird, Denechere and Fons (2002). The CORE LOC™ armouring technique experience on eight recent projects, *Proceedings of 28th ICCE 2002, Cardiff, Wales.*

KEYWORDS – ICCE 2008

ADVANCED SYSTEM FOR VISUALISING PLACEMENT OF ARMOUR UNITS UNDERWATER
Mr. Michel Fons and Mr. Michel Denechere
Abstract number 847

Positioning system
Underwater placement
Rubble round breakwaters
Single layer armour units
Primary armour
Artificial armour units
Interlocking
Packing density
Water visibility
3D visualisation