Considerations about the selections of equipment and work method

Review of the IEG comments related to scouring in the Entrance

Review by Frans Uelman (Boskalis)

1 Introduction

The paper "Best Practice for Dredging Uncontaminated and Contaminated Material" (SEES Appendix 19) describes the selection of the type of dredging equipment for the Channel Deepening Project. Assessments were undertaken for all project areas and involved the evaluation of technical, economic, environmental and social criteria. From the analysis it was concluded that use of a trailer suction hopper dredger (TSHD) in conjunction with hydro-hammer for harder spots is the preferred approach.

The issue of rockfall from dredging received detailed attention during the SEES process, following the outcomes of the Trial Dredge Program. While this concern was not due to scour, the need to minimise rock spill into the marine environment at the Entrance has been at the forefront of technological innovations and work method development during SEES preparation.

The paper "Techniques and Strategies for Reduction of Rockfall during Entrance Dredging" (SEES Appendix 21) presented previously to the IEG, describes a number of options for the work method of the selected equipment taking into account the circumstances in the Entrance such as metocean conditions, geology and environmental concerns. As observed during and after the trial, rock lumps left behind after dredging had been identified as the main reason for rockfall in the canyon, which is the main environmental concern. Following a multi criteria analysis, the preferred work method was determined to comprise;

- Dredging away from the canyon using a modified ripper draghead.
- Use of ridges along the north-west side of Nepean Bank to provide added protection to the Port Phillip Heads National Park.
- Use of clean-up dredging to remove loose rock.

The "Scour Assessment Report, The Entrance" (SKM, Don Raisbeck, July 2007) describes the post trial dredging scouring in the Entrance and identifies blasting and dredging as initiating processes. Rock lumps left behind on the plateau and their interaction with the geology and hydrodynamics of the area were recognised to exacerbate scouring.

While the SKM report does not in any way address the issue of dredging technologies and methodologies, the peer review requested by the Dr Allan Hawke, Chair, Port Phillip Bay Channel Deepening Project Supplementary EES Inquiry by letter to PoMC dated 27 July 2007 identified the need for a person with expertise in these fields to contribute to a peer review of the report.

Acknowledging the scarcity of independent expertise in dredging technologies, the extent of technical investigation already undertaken or commissioned by Boskalis in relation to minimising the generation of loose rock in the Entrance, and the absence of any comment or conclusions in the Report specific to dredging, Boskalis has contributed its expertise to the peer review.

2 Scope of the Review

In the light of the new information contained in the Scour Assessment Report it was considered appropriate to review previous decisions in relation to selection of the dredging technology and dredging method for the Entrance. The review has focussed on the following questions:

Is the decision on the dredging technology to be used for dredging at the Entrance still valid in the light of new information on rock scour?

Does the selected work method for dredging at the Entrance need to be modified in response to new information on rock scour?

3 Selection of dredging technology for the Entrance.

In the paper "Best Practice for Dredging Uncontaminated and Contaminated Material" (SEES Appendix 19) a trailing suction hopper dredger (TSHD) is compared with a cutter suction dredger (CSD). The selection criteria applied concern environmental, social and economic aspects.

The list of criteria includes:

- Environmental: - Turbidity, Underwater Noise, Rockfall, Quantity, Duration
- Social: - Collision Risk, Weather Vulnerability, Noise, Shipping, Security
- Economic: - Cost, Excavation, Disposal, Flexibility

Against the social and economic criteria, there is a clear preference for the TSHD. For the environmental criteria not related to turbidity only the difference in duration is substantial, as a TSHD is considerably less affected by adverse metocean conditions than a CSD.

Regarding scouring the following aspects are relevant:

- Cutting level.
- Amount of spill produced.
- Cleaning-up capability.

As the CSD has to cut considerably deeper than a TSHD to achieve the required depth in an effective way, the CSD will cause a higher level of rock spill. With a considerable amount of effort, this spill can be reduced (i.e. by additional swings without cutting). Notwithstanding this potential mitigation, the amount of spill from the CSD would exceed that from the TSHD.

As mentioned above, it is likely that a CSD will cut deeper levels than required. In contrast, a TSHD equipped with a ripper drag head is a more efficient tool as the amount of sucked material is nearly the same as the amount of cut material.

Evaluating these influences with respect to scour, it is concluded that a TSHD with ripper draghead is still the preferred equipment. In fact, the issue of scour provides an additional reason to select the TSHD over the CSD.

With respect of the possible effects of shockwaves from mechanical equipment inducing fractures in the rock, reference is made to the attached document which comments on the effects of surface blasting. The information indicates that the layered geology prohibits penetration of shockwaves – they will be reflected rather than penetrate. As a consequence, significant pressure wave induced fractures are not expected.

It should be noted that the blasting induced pressure waves, especially those from the 250 kg sea mines, are much more forceful than the mechanical tools. In addition, if comparing a CSD and a TSHD, the forces caused by a CSD would be higher than those caused by a ripper draghead. Vertical forces applied by a ripper draghead are caused by its weight, whereas in the case of a CSD the entire vessel's mass contributes to these forces. Therefore there would be greater impact or force to the surface by a CSD.

Regarding damage from previous blasting campaigns, the previous blasting work done in the Entrance is understood to have been by surface blasting. These methods do not maximise the energy applied to the rock mass, with a large part of the energy lost into the water. Because rock at the Entrance is porous, weak and ductile the damage zone is expected to be limited to an area relatively near the blasting source and likely to extend less than one metre below the source.

4 Selection of work method for a TSHD in the Entrance

The paper "Techniques and Strategies for Reduction of Rockfall during Entrance Dredging" (SEES Appendix 21) describes a number of options for the work method of the selected equipment taking into account the circumstances in the Entrance such as metocean conditions, geology and environmental concerns.

The options considered included: dredging similar to the trial, using an improved ripper draghead, including clean up, leaving ridges near the edge of the canyon as the last area to be removed and creation of deeper areas for catching loose material. The creation of ridges and catchment areas was found to be of limited environmental benefit but would substantially increase cost. It should be noted that the latter two mitigation measures are meant to reduce the amount of material to be moved over the edge of the canyon during dredging. As scouring develops after dredging, these mitigation measures are not relevant to scouring.

Scour holes are similar to catchment areas. As explained in the Scour Assessment Report (SKM 2007), scour holes are envisaged to stabilise and eventually trap loose material. This material will stay in the scour hole and act as sort of stable armour layer.

The selected option is dredging with an improved draghead alternating with clean-up. In addition, in order to reduce rockfall into the Marine Park, a ridge will be left in place on Nepean Bank as the last part to be excavated.

If scouring is taken into account, the following should be considered:

- Weaker strata cannot be detected during dredging and locations of weaker spots are unknown. Therefore, an anticipating strategy, if any, cannot be developed nor be applied.
- Clean-up is part of the proposed work method. Clean-up reduces the amount of loose material left behind and therefore inherently reduces scour initiation. The proposed clean-up method with the TSHD is the most effective way to mitigate spill as much as practicable.
- The ripper draghead scrapes off relatively thin layers; the shorter visors are used. The excavation method by means of ripper dragheads is effective in this kind of geology. The thickness of the scraped off layers is of the same order of magnitude as the sub bottom layers.

As a consequence no identified improvements have surfaced during this review. The selected work methods outlined in the EMP are appropriate and are considered to be optimal.

5 Conclusion

Previous decisions regarding selection of dredging technology and dredging work method have been reviewed in the light of new information in relation to rock scour at the Entrance. The results show that the conclusions of previous analyses are unchanged.

Use of TSHD in conjunction with hydro-hammer for harder spots remains the preferred dredging technology. The dredging method proposed in the SEES involving improved draghead design, use of ridges and clean-up of loose rock remains the preferred dredging method. In particular, the proposed clean-up method with the TSHD as outlined in the EMP is the most effective way to mitigate spill as much as practicable.

Attachment

Boskalis International bv

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To	From	Date
Frans Uelman	Peter Verhoef	13 September 2007
Copy	**Reference**	
	pnve20070913	

Memo

Subject: Expected blasting damage in dune calcarenites

The effects of blasting on rock are best known from experience with the drilling and blasting method used for rock excavation. This general knowledge will be used in this memo to interpret the effects expected from the surface blasting used in the past for underwater fragmentation of the dune calcarenite rocks at the Entrance of Port Phillip Bay.

Damage from blasting around a borehole in a rock is due to:

- Crushing of rock due to the compression wave in a zone directly around the borehole (the width of this zone often less than the borehole diameter)
- Radial cracks growing from blast source due to gas release from the explosion (order of up to several times borehole diameter)
- Tensile cracks tangential to blast wave due to rebound and reflecting waves after the compressive wave has passed

The amount of direct blast damage is dependent on the elasticity and brittleness of the rock and of the existence of pre-existing defect structures in the rock, such as layer plane separations and joints. Pre-existing defect planes can act as reflectors for the stress waves of the blast, so that no damage occurs behind these planes. (This is purposely used in so-called pre-splitting blasting for road cuts: a closely spaced parallel array of boreholes charged with carefully stemmed light explosives is detonated to provide a continuous fracture surface, which acts as a reflector to the following main blast to fragment the bulk of the rock to be removed. In a successful pre-splitting blasting operation damage behind the pre-split slope face is minimal.)

One of the difficulties with blasting operations is to get the blast stress waves into the ground. Therefore the correct stemming of the boreholes is an item. Otherwise the explosive energy would be lost to the surface (seabed in underwater blasting). Fragmentation is often confined to an area near the borehole. Borehole spacing is critical and is often of the order of a meter or less. In blasting of hard rock for dredging, the depth of the boreholes is commonly a meter below the target dredging depth, because fragmentation is mainly in between the boreholes and limited below the bottom elevation of the boreholes.

Regarding the situation at the Entrance, the following points can be taken into consideration:

- The rock is porous, weak and ductile. This will limit the extend of the damage zone to relatively near the blasting source (compared to the usually blasted strong and brittle rock)
- Considering the previous blasting work done in the Entrance (I understand from 1904-1985 using various types of explosives, including military mines); these methods were by surface blasting. Surface blasting methods that are not designed to put as much energy as possible into the rock mass, will loose the largest part of their energy into the water.

Concluding, I expect that blasting damage is confined to a zone near the blasting source used and will not extend deep below the blasting source location; likely less than a meter.