

Icelandic Maritime Administration
Bakkafjara Ferry Port
Review of IMA provided reports

COWI A/S
Parallevej 2
DK-2800 Kongens Lyngby
Denmark
Tel +45 45 97 22 11
Fax +45 45 97 22 12
www.cowi.com

Table of Contents

1	General	1
2	Findings on Ref [1] "Ferjuhöfn við Bakkafjöru"	3
3	Findings on Ref [2] "Sediment Transport and Morphology"	6
4	Findings on Ref [3] "Risk Assessment of Ferry Bakkafjara - Vestmannaeyjar" . Report No. 2161-2006. Revision No.02. January 2007. Det Norske Veritas	7
5	Findings on "Bakkafjörühöfn. Grjótrannsókn 2006"	8

1 General

Background

By e-mail with appendices dated 15 February 2007, COWI was requested by the Icelandic Maritime Administration (IMA) to undertake a review of various reports prepared by or for IMA. These reports form part of the planning and decision-making basis for the planned new ferry port at Bakkafjöru at the south coast of Iceland, vis-à-vis the Vestmannaeyjar, the destination of the ferry line.

After clarifications, the final scope as described in COWI's proposal ATR #1 "Bakkafjara Ferry Port Project Review" dated 20 Feb 2007 was accepted by IMA 22 Feb 2007. The scope is summarized thus:

Scope

Undertaking a second opinion desk study concerning the proposed Bakkafjara ferry and ferry harbour with respect to the questions:

1. Are the studies of accepted standards?
2. Is the evaluation of the sediment transport and morphology realistic?
3. Is the risk assessment of the ferry realistic?
4. Are there any weaknesses in the studies which require further improvements for the project basis?

Comments on scope

It is understood that the said documents are IMA contributions to the design

Document no.	P-65521-01
Issue no.	0
Date of issue	02 Mar 2007
Prepared	JOT, DO, CEL
Checked	JOT
Approved	JOT

and planning basis, while others are providing other aspects of the complete basis, such as full environmental impact assessment (EIA).

The review shall therefore consider the received reports in their own right, with the underlying assumption that comments and recommendations are limited to the frame of the received documents.

Further it is noted that the scope of services shall not include quality control on quantitative or qualitative results and conclusions - which remain the responsibility of IMA - but rather assesses the adequacy and completeness of the scope and methodologies applied to the investigations.

General observations

It is noted that 1) IMA has developed an innovative approach to establishing criteria for safe navigation in rough waters; 2) Iceland holds an international reputation for being leader in design and construction of berm breakwaters. As a consequence, these two issues are considered being at a high level relative to general practice, and comments should be read in this light.

The overall project objective is to establish a shorter and more time-efficient ferry route, namely by construction of a new ferry port at Bakkafjörur at 6-7 nm distance from Vestmannaeyar, as compared to the app. 40 nm to the present ferry port at Thorlakshöfn.

However, the Bakkafjörur location is a littoral drift shore with a sand reef in front, neighbouring the meandering delta of the river Markafljót. Further, although some shelter is provided to the location from the Vestmannaeyar, the port will be situated at an open coast, subject to sea waves from SE and SW.

The challenging environment has caused focus to be on the two crucial issues:

- impact on and from the sediment transport
- navigational safety and security to passengers and vessel, in combination with down time considerations

Several other issues are addressed in Ref [1], cf. chapter 2.

In summary, questions 1 through 4 above may be summarised thus:

1. The studies reviewed are of accepted standards, and on certain points on a high level
2. The studies on sediment transport and morphology are considered realistic. However, certain aspects have been identified which are recommended to be included in the next stage of the project
3. Also the studies on risk assessment of the ferry are considered being realistic
4. The overall impression is that the studies reviewed are adequate for the current stage of planning development. With a view to the next stages, each chapter is concluded by recommendations for further detailing of the specific issues reviewed.

2 Findings on Ref [1] "Ferjuhöfn við Bakkafjöru"

Full title of report: "Ferjuhöfn við Bakkafjöru", Áfangaskýrsla um rannsóknir og tillögur. Febrúar 2006. Siglingastofnun Íslands, with drawings.

The report contains a description of the comprehensive pre-investigations carried out at the time of reporting. To a great extent these investigations concerned the important sediment transport issues, which have later been dealt with in details in Ref [2]. Comments on these aspects are referred to chapter 3.

The review notes are given by the section numbering of Ref [1]

- Ref [1] Chapter 1 is a general introduction.
- Ref [1] Chapter 2 contains summary and conclusions
- Ref [1] Chapter 3 gives a historical review of the project development from year 2000 and on, both technical and legal.
- Ref [1] Chapter 4 is a narrative description of the characteristics of Bakkafjara site, focusing on sediment transport conditions including waves.
- Ref [1] Chapter 5 gives a summary of the site selection considerations. It appears that an off-shore port with bridge-dam shore connection was considered at an early stage. The concept turned out to be overly expensive without offering any special advantages. It was specifically addressed during the ICS2005 symposium among a group of international experts.
- Also an early layout of the Bakkafjara location is shown, which however has developed further to accommodate the navigational and sediment transport challenges at the site.
- Ref [1] Chapter 6 provides a description and comparison between the sailing routes from Vestmannaeyar to Thorlakshöfn and Bakkafjör, respectively.
- A detailed description of the coastal morphology is provided, based on aerial photographs from 1956 and on, bathymetric soundings repeated at different seasons. Thus both the long term coastline variability and seasonal variation in shore profiles are addressed. This includes the sandbar and the depression found at it.
- Ref [1] Chapter 7 reports the wave measurement. These are quite comprehensive, as long term regional measurements have been carried out at nearby Surtsey 1988-2004, and at Bakkafjöru 2003-2006 (at the time of reporting). These data have been supplemented with data from international wave data bases, providing a wider range of data, especially wave directional data.
- The data have been consolidated into long term wave forecast, detailed to the general accepted standards (scatter, seasonal, return period).

It is noted that the measurement are non-directional.

Ref [1] Chapter 8

present the wave modelling carried out. Based on the wave data above, the boundary waves have been applied to first a coarse grid, modelling a wider geographic 80x80 km² area including Vestmannaeyjar, a more detailed grid covering an area of 20x20 km² around Vestmannaeyjar, and finally a nearshore grid adjacent to Bakkafjörú.

The wave parameters are then extracted for a number of characteristic points along perpendiculars to the Bakkafjara coast, giving the wave height variation along the sailing route for the range of sea conditions investigated. Also the sheltering effect of Vestmannaeyjar is demonstrated.

This approach is accepted practise.

No details are provided on the program used. It appears that the phenomenon of crossing waves on the lee side of Vestmannaeyjar is not discussed in this report, but IMA has informed that this was done subsequently, with the conclusion that the international data obtained on wave directionality was sufficient for the purposes of navigation and sediment transport assessments.

Ref [1] Chapter 9

introduces the basics for the down time estimation further developed in the subsequent chapters. Focus is on combinations of breaking waves over the reefs, water depths and water levels, including comparison with Grindavik and Thorlakshöfn harbours. The latter harbours are specifically relevant because approaches are over reefs as is the case in Bakkafjara.

The methodology appears to be sound. It should be noted that it is innovative and specific for Icelandic conditions and traditions. As such, no general standards exist to compare against.

Ref [1] Chapter 10

defines the design width of the access channel and the port entrance. The channel width is determined in accordance with PIANC "Approach Channels, Preliminary Guidelines" (1995). The PIANC guidelines are internationally accepted standards. This document is issued in a final version in 1997, which is identical to the preliminary version on the issues considered in Ref [1].

Due to the cross current (rib current) present at the harbour entrance, section 10.3 of Ref [1] assesses the required entrance width in this regard. It is understood that the formula applied is based on criteria established for the Danish port Hanstholm facing the North Sea. It is further understood that the entrance width has been increased to 90 m due to the increase in ferry breadth to 15 m adopted since the issue of Ref [1]. It is further understood that the entrance will be rubble mound heads supplemented with fender dolphins along the entrance to provide protection to the ferry during approach.

The methodology is in accordance with accepted standards for the actual planning level. See also comment to Ref [1] Chapter 13.

Ref [1] Chapter 11 is listing of requirements to the ferry to meet the conditions while navigating cross the reef (sandbar) at Bakkafjörú. It is understood that these requirements have been further detailed later. It is outside COWI's scope to evaluate vessel design issues, as we do not possess any naval architectural expertise. However, we confirm the importance of specifications for the vessel being compatible with the navigational conditions prevailing on the route.

Ref [1] Chapter 12 is a narrative description of the ferry port project at Bakkafjörú, including design considerations. It is noted that a prerequisite for the project is fixation of the Markarfljót outlet, which is important for the sedimentation processes.

It is noted that the ferry dimensions have increased since the issue of Ref [1]. Hence, it is assumed that the dimensions of the berth and turning circle will be adjusted accordingly.

Under this assumption, the description is considered adequate for the current project level.

Ref [1] Chapter 13 presents the results of the physical model tests with a model ferry actually navigating over the reef and into the harbour. The tests were carried out at IMA's facilities, the model ferry remotely controlled by a captain experienced in navigating Vestmannayjar-Thorlakshöfn. This approach is reported to have been applied earlier for Grindavík harbour, and the ferry model was reused from those tests. It is understood that although the model ferry fulfilled the criteria for capacity of passenger and cars proposed in chapter 14.3.1, the one later proposed to be built for Bakkafjörú is actually somewhat larger. The model tests may be considered yielding conservative results.

The comprehensive test programme considered variations in sea states and water levels, wave measurements along the sailing routes, counting of number of breaking waves vs. wave-waterdepth, and registration of the captains evaluation of the safety conditions for the various conditions. No cross current was applied for model technique reasons. At the time of reporting, wave direction was South for all waves. It is informed that after publication of the report in February 2006, the model tests continued with wave directions from southwest and southeast for establishing safety criteria for navigating the remotely operated model. Wave height criteria at the design water level were also established. The evaluation of the criteria regarding the significant wave height at the Wave rider buoy are reported in chapter 5 in Ref. [2].

By this methodology, criteria for acceptable wave condition for passing the reef and approaching the harbour have been established.

As mentioned above, this methodology is unique for Iceland, and as such can not be compared to any general standard. Since the method has been applied in Iceland before in Grindavik, and experienced navigators have assessed the conditions, it is assessed that plausible criteria are arrived at. (see also comments to Chapter 14 of Ref [1]).

Ref [1] Chapter 14 gives the conclusion of the model tests and establishes weather down time estimates for navigating the Bakkafjara Ferry Port. Also an independent assessment of the approach conditions in question by a captain with thorough experience from the similar conditions at Grindavik is reported. It appears that the down time is somewhat higher than compared with experience from the current route to Thorlakshöfn, which however is weighed against the higher frequency and the opportunity to wait for improved conditions.

The methodology is assessed to give plausible weather down time estimates.

Ref [1] Chapter 15 presents the outline design of the berm breakwater planned for the Bakkafjara Ferry Port.

The design appear to be in accordance with general practise, and the level of detail adequate for the current project stage.

Ref [1] Chapter 16 presents the list of planned investigations. The list appears to be adequate, except that geotechnical investigations for the structural design of the port structures should be included. Some supplementary investigations for the detailed design are suggested by COWI below.

Ref [1] Chapter 17 gives a cost estimate of the planned Bakkafjara development. No assessment of the cost estimate has been carried out by COWI.

Comments and recommendations The report is comprehensive and in accordance with accepted standards. The navigation and down estimates are special Icelandic practise based on Icelandic experience, and no international standards for these condition are known to COWI. The methodology and conclusions appear to be sound and justified.

It is assumed that geotechnical investigations will be included in the detailed design phase.

Due to the unique character of the development, it is recommended in the detailed design phase to include navigation computer simulation - including wind, waves and currents - of the approach to the port inside the reef. To the extent possible, crossing wave effects should be included.

A computer model has the advantage of including wind and combined wave and current effect, neither of which are feasible in a physical model.

Further, the simulation model provides a tool for training captains and finally the simulations could be merged into the detailing of the risk assessment suggested in chapter 4

3 Findings on Ref [2] "Sediment Transport and Morphology"

Full title of report: "Sediment Transport and Morphology" Final Report. February 2007. DHI, Water & Environment.

The study been carried out by application of state-of-art computer models (MIKE 21 FM, LITLINE), and a detailed morphological model. The software is developed by DHI, which is recognized as an international leader in the field.

The study includes validation of wave prediction.

The study is found to comprehensive and yielding realistic result. Thus, the study is considered adequate for the current level of project development.

Due to the importance of the sediment transport for the project, it is recommended that the detailed design include more scenarios. This could form a natural part of the planned environmental impact assessment.

Such scenarios could include sensitivity analyses of:

- the river as a sediment supply source
- water level variations, including long term effects from global warming
- sensitivity for grain size variations identified by the planned supplementing sediment sampling
- effect on the wave conditions along the navigation route vis-à-vis natural variation of sand bar bathymetry

and

- further detailing of the long term morphological changes

4 Findings on Ref [3] "Risk Assessment of Ferry Bakkafjara - Vestmannaeyjar"

Full title of report: "Risk Assessment of Ferry Bakkafjara - Vestmannaeyjar" . Report No. 2161-2006. Revision No.02. January 2007. Det Norske Veritas

Evaluation and Conclusion

The formal safety methodology and coverage have been found to be generally suited to meet the objective.

The quantitative analyses are based on generic values established by DNV and adopted to the specific project conditions.

The conclusions and the recommendations appear to be reasonable in general.

It can be concluded that the quantitative risk assessment is adequate in itself.

Recommendations

Uncertainties in the generic values established by DNV and analyses are inherent, and the adoption to the specific conditions is consequently associated with some uncertainty.

On the other hand, IMA has in Ref [1] included detailed assessments via physical model and maritime experts of the suitability of the proposed ferry and of the specific navigation conditions of the new ferry route.

We recommend that the risk assessment and the maritime assessments be closer combined in the next stage of the project. Particularly, that the safety critical aspects are further studied by experts in co-operation with local mariners.

The navigation simulations proposed in chapter 2 would provide valuable input to such detailing, together with the elaborate wave and navigations statistics established through the comprehensive model tests at IMA. It is believed this material would allow for a more precise quantification than generic data can.

The main objective of such subsequent work would be to further substantiate that the ferry to be selected will be able to operate safely under all but the most extreme conditions.

5 Findings on "Bakkafjörühöfn. Grjótrannsókn 2006"

Full title of report: "Bakkafjörühöfn. Grjótrannsókn 2006", Janúar 2007, Stapi Jarðfræðistofa.

This report describes the investigations carried out for quarry prospecting. It contains:

- a geological description, describing the wider geological context
- boring programme and results
- interpretation of the results
- appendix with bore hole profiles with test results, and pictures of the samples

Hence, the report is adequate and in accordance with good practise for geotechnical investigation.