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Venice gates hydrodynamic analysis

PRINCIPIA

Request of information on Principia Report.

Clarifications from Principia in the text (in blue)

General Comments

1. Please confirm the validity of the mathematical model used for the dynamic analysis of the gate system, and what are the limits for the analysis. At pag. 8 of the summary it is stated that the "amplitudes …… cannot be represented with the state of the art of modelling and analysis" and in the following where it is stated "…it is very difficult to define a mathematical model that represent the real behaviour of the unstable gate".
   Can you please better explain these points?
   For systems having a normal or better regular dynamic behaviour in the design sea state, the mathematical model used reproduces in a realistic way their dynamic response. This is the case of the gate alone or of the two gates close to the barrier as for the Gravity gates for all the conditions examined and for the MoSE gates with sea state for which the instability does not occur.
   Where instability occurs the mathematical model is able to detect the presence of the phenomenon but is not able to reproduce the corresponding dynamic behaviour. This is the only limit for the numerical modelling of the methodology used. This limit is coherent with needs of design as when instability is detected, the design is modified to avoid it.
   This means the limits for the present analysis is not related to the software used (largely referenced in marine engineering) but to the dynamic characteristics of the system.

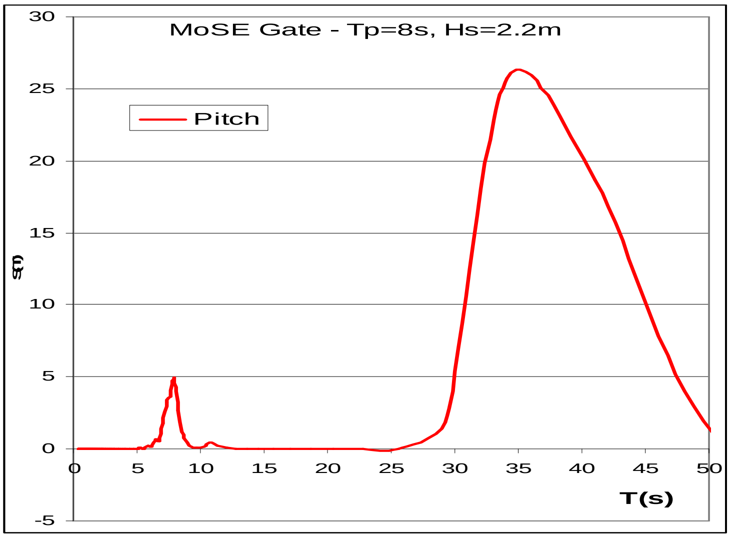
2. Please explain the reasons why only one and two adjacent gates have been used for the comparison of the two gate systems with non linear analysis.
   Is this due to the limitation of the mathematical model?
   The non linear mathematical model is able to simulate the whole barrier behaviour. However numerical simulations for the whole barrier (20 gates) have not been performed for the following reasons:
   - The existing version of the software is foreseen the modelling of 5 elements (gates). Modelling more elements is possible increasing the software capabilities (no difficulty but it requires some time)
   - Simulations of a whole barrier will require a large time consuming on standard computers which was not compatible with the number of cases required for the comparative analysis
   - Considering that the behaviour of a gate in the barrier is affected, mainly by its hydrostatic characteristic, the direct wave action and by the effect of the waves generated by the adjacent gates having he same period of the incident wave, and that, for the MoSE gate, the benefit of the presence of the wall experienced with the simulation of the single gate close to the barrier vanishes for the second one, it has been considered useless to proceed with the whole MoSE barrier. In addition, considering that the scope of the work was the dynamic analysis of the two barrier systems and not the design of the gate system, it has been considered that the results achieved were sufficient to show the significantly different dynamic behaviour of the two gates, and therefore that it was useless to proceed with these calculations.
     A more complete analysis would not give further informations.

3. Please indicate why the dynamic analysis performed does not include the presence of the current. Presence of current is expected during the closing and the opening manoeuvres.
   At the beginning of the study current has been considered as a major parameter. Current will influence both the inclination of the gates and the wave conditions during the manoeuvring of the gates where current exists. However we have assumed that ballasting of the gates is used to counteract the current force.
   The scope of the work of the performed study is the dynamic analysis of the whole barriers in working conditions, at the closure of the gates with the same water depth on both sides of the barrier and with the maximum differential depth corresponding to a tide excursion of 2 m, and in this condition, of course, there is no current acting on the gates. Current can be included if further investigations on the manoeuvring of the gates are needed.

4. Please confirm that the comments / evaluations reflect the results of diagrams (green and red).
   The diagrams provided in the report reflect the performance of each gate systems in term of motions and loads within the applicability of the mathematical model used. When instability is occurred and detected by the model, results are given only to illustrate the instability but amplitudes of motions are not realistic (see previous comments).

Specific Comments

- Pag 8. The first bullet seems to shadow the advantage of MoSE gates. The sentence "For larger value the gate oscillates between two instable equilibrium inclinations .. " seems not represented in the annexed plotters.
  Can you please explain and give evidence of this statement?
  Referring to the plots given on pages 26 and 27, I has been concluded that :
  – Mean inclination of the MoSE gate is not the same for the two sea state (Hs=2.0m and Hs=2.2m)
  – Stable behaviour is obtained for Tp=8.0s and Hs=2.0m instead of an instability occurrence (large unrealistic amplitudes) for Hs=2.2m
  Next plot of the spectral analysis of the time simulation illustrates the instability occurrence. Peaks are observed at both the wave excitation period (peak of the wave spectrum) and peak at the gate natural period (even if this peak is out of the range of the wave periods).



In conclusion, until sea state conditions is limited to Tp > 9s or Hs<2.0m for Tp<9s the MoSE gate remains a good design (see hereafter).

- Pag. 9. General Comment
  General comment first bullet. The sentence " With the ……….. MoSE gate shows ……… an unstable behaviour not only with max. ……. But also with less severe sea states" seems too generic and not supported by the results of the study.
  Can you please clarify?
  As mentioned before, analysis concludes that the MoSE gates behaviour has a limitation in terms of sea states :
  – Tp > 9.0s and Hs < 3.2m : normal expected behaviour is obtained with no critical results
  – Tp = 8.0s and Hs = 3.2 the system shows instability.

  In order to check the range of instability a sensitivity analysis has been performed to check the limit, in terms of wave height, the starting of this phenomenon and this has been found at Hs = 2,2m. A further sensitivity check has been performed introducing additional damping in the mathematical model (instability is largely influenced by the damping induced by the flow in between the gates).
  As results from calculations for Tp < 9.0s and Hs > 2.0m the risk of instability exists.
  This conclusion is supported by plots given on pages 26 and 27.
  Of course in this cases only model tests in large scale and an appropriate test procedure can better define the range of this instability but this is not the scope of the present work.

Required explanations

Please give a more explanatory wording of the following sentences:

- Pag. 15, MoSE Gate
  In absence of mass characteristics of the gate, autocad model has been done, a section is reported below.
  That means that, starting from the design drawings of the MoSE gate, it has been considered useful to have the autocad model to obtain the proper mass distribution and to estimate the gate inertia needed for the analysis. The auto cad model of the Gravity gate was provided by the designers, and was an input of the study (specifications).

- Pag. 19, point 5.2
  Upstream and downstream water depth are assumed equal for wave loads prediction.
  In fact, this assumption is done only for the 3D wave loads estimation used in the non linear calculations and is perfectly applicable to the conditions examined with non linear analysis at the starting conditions of the closure of the gates when the water depth is 15 m.
  For linear analysis of the multi-gates configuration difference between upstream and downstream water depth has been considered.

- Pag. 23
  Please clarify the comments to the plotters and to the RAOs.
  Referring to the plots provided on pages 23 and 24, it has be concluded that :
  – Gravity gate leads to larger motion amplitudes than for the MoSE gate
  – Vertical force and mean wave force (drift) are smaller for the Gravity gate than for the MoSE gate

  - RAO corresponds to the linear motion of the gates : rotation amplitude for 1meter wave amplitude. It can be observed that Gravity gate leads to quite larger motions than for the MoSE gate for the full range of wave period if non linear effects are neglected.

- Pag. 25

  Please clarify the comments to the plotters.

  The rotation of the gate under wave action is composed of two contributions:

  - A mean inclination within the initial position induced by the mean wave loads (drift). As expected this contribution leads to increase the Gravity gate inclination versus the bottom and to reduce it for the MoSE gate. Free-board considered here is the height of the gate remaining in air.
  - The dynamic contribution which corresponds to the wave induced motions at wave frequency. Amplitudes around the mean inclination are similar for both gates.

- Pag. 34

  Please explain better first and third bullets.

  Natural periods of MoSE gates, including gates interference, are smaller than the Gravity gates natural periods. However these natural periods remain larger than the wave periods which limits the risk of pure resonance occurring when wave load period corresponds to natural period.

- Pag. 35

  First bullet, please explain the sentence: “It looks like the Gravity concept is thus superior to the MoSE concept.”

  It means that natural periods of the MoSE gates is closer to the wave periods than the natural periods of the Gravity gates.

  Last bullet, please explain the last sentence: “The calculation with reduced stiffness…… and it is considered the best design achievable for the buoyant concept.”

  Instead of the Gravity gate, the weight distribution of the MoSE gate is adjusted to fix the mean inclination. Then its natural period is depending of the ballasting conditions.

  In fact the influence of the ballasting system would be considered to obtain the proper resonance period for each sea-state.

  The sensitivity analysis has considered the smaller hydrostatic stiffness and then the larger natural period. Assuming that the automatic ballasting system is well optimized and considering that the MoSE gate geometry is derived from the final design drawings this has to be considered only an academic exercise. In fact the assumption done here, therefore is not coherent with the final design of the MoSE and is not necessarily conservative. (I would delete the last sentence)

- Pag 37

  Please detail the reasons for which the modelling of the non linear behaviour that it is possible in pure resonance is not possible in this case, and if the limitation for the numerical simulation is due to the limits of the existing software or to the characteristics of the gates.

  The non linear mathematical model is able to simulate the whole barrier behaviour. However numerical simulations for the whole barrier (20 gates) have not been performed for the reasons given previously (general comments). As mentioned also before, the results obtained from the non linear simulations in case of instability are not realistic which is firstly due to the design itself. Numerical models are not able to predict very large motions as marine design is generally focused of floater with reduced motions. In case of pure resonance, as for the rolling of ships, either linear and non linear simulations are used to represent the dynamic behaviour of the body.

- Pag.42, last sentence.
  Please give evidence of the statement introduced with the wording: "This confirm …… if the gate is stable the barrier does not introduce instability or sub-harmonics."
  One conclusion of the analysis is that the instability is induced by the non linear hydrostatic stiffness of the gate itself which is not affected by the presence of the other gates.
  Simulations done with one gate alone and two gates have shown small difference in case of regular behaviour as for the Gravity gates.
  In fact, as the range of the instability is influenced by the flow damping, it could be anticipated that the flow interaction between gates could lead to reduce the instability occurrence as it is the case of model tests in small scale. However to confirm this assumption and to better define the range of the instability, more investigations are needed on the hydrodynamic damping to be considered.