Theme E

Acceptance Criteria • Accepted Risk Levels

Chairman

Mr. J.A. Leslie

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Technical Programme

The following papers were presented:

- W.D. Rowe, U.S.A
  Acceptance Levels of Risk for Technological Undertakings.

- J.-M. Planeix, France
  Risk - A subjective Notion Differently Perceived.

- W. von Olnhausen, Sweden
  Ship Collisions with Bridges in Sweden.

- J.A. Leslie, N. Clark, L. Segal, Australia
  Ship and Bridge Collisions - The Economics of Risk.
  Presented by Mr. J.A. Leslie.

- R.G. Sexsmith, Canada
  Bridge Risk Assessment and Protective Design for Ship Collision.

- M. Knott, M. Flanagan, U.S.A
  Pier Protection for the Sunshine Skyway Bridge.
  Presented by Mr. M. Knott.

Discussion and Comments

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Paper Title : Risk - A Subjective Notion Differently Perceived.
Presented by: Dr. J.-M. Planeix, Bureau Veritas, France

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Discussion by: Dr. J.S. Gardenier, U.S. Coast Guard, U.S.A.

It is not appropriate to devote very large amounts of analytic funding to refining probabilities precisely. The authors have correctly indicated both that risk estimates may be subject to large uncertainties and that risk acceptance is perceived very differently by various people due to their differing values and perceptions.

What should be done is to manage risks, rather than accept them. As Dr. Planeix has said, we should focus on reducing the effects of sets of causes.

To aid this process, we should devote much effort and patience to understand other peoples problems and perceptions with a project. Bridge engineers should talk to pilots, port authorities should talk to road authorities, and so forth. Consensus is possible, but not if each group talks only to themselves.

Answer by: Dr. J.-M. Planeix.

I am grateful to Dr. Gardenier for his comment on my introductory paper. Dr. Gardenier rightly points out to the need to manage risk, rather than more or less blindly accepting it. His recommendation to devote much effort and patience to the understanding of the problems (I believe he means: "problems relative to some particular subjective perception of risk") of all parties involved in a project is specially interesting and amounts to advocating a general education of the public on risk, which should, in our view, begin at school.

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Paper Title : Ship Collisions with Bridges in Sweden
Presented by: Mr. W. von Olnhausen, Swedish National Road Administration, Sweden.

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Extract of oral presentation by Mr. W. von Olnhausen.

In the preliminary report of the colloquium, page 409 ff, you can find my paper, "Ship Collisions with Bridges in Sweden". The paper gives some facts about five ship collisions with bridges, which have happened in Sweden since 1965. Beside the facts some conclusions have been drawn from the accidents by the National Swedish Road Administration, namely to make some regulations for design forces due to ship collisions - adopted on all new bridges since 1967 - and to make a study of all Swedish bridges with regard to collision risks. This study was made after the Tjörn Bridge disaster in 1980.

The most remarkable accident in Sweden was in January 1980, when the 278 m steel arch of the Tjörn Bridge, near Gothenburg, totally collapsed. A photo of the bridge can be found in my paper. It consists of two 14-22 mm thick plate tubes, ø 3,8 m each, connected by a lattice girder structure. The tubeform gives the advantage that no longitudional stiffeners are necessary in the arch. The cross-section is shown in fig. 1. This section gives good economy but is on the other hand extremely sensitive for an impact of a local concentrated load. Fig. 2 gives a survey of the location of the bridge, related to the cities of Gothenburg and Uddevalla, and Fig. 3 shows the course of the colliding vessel - a 27 000 dwt cargo ship, actually loaded to 15 000 t - during the last 5 minutes before the impact.

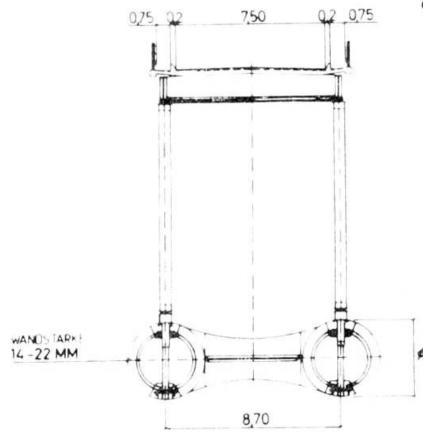

Fig. 1
The old Tjörn Bridge Cross Section.

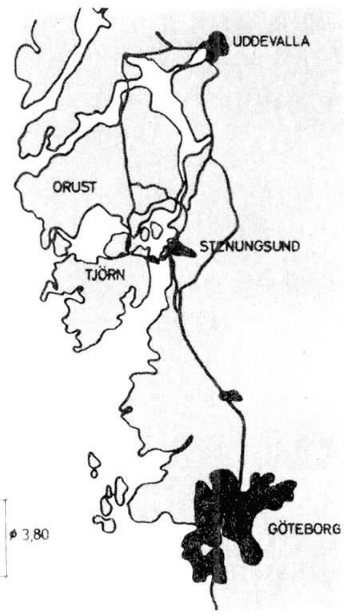

Fig. 2
Location of the Tjörn Bridge

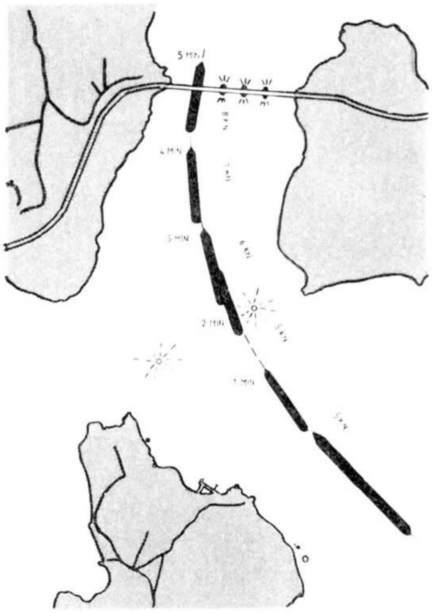

Fig. 3
The course of the colliding vessel.

She was on the right course 3 min. before the accident, but in a position too far west. A correcting manoeuvre did not succeed because of ice hindrance, in spite of using full machine power. You can see the margins are very small. She hit the arch about 35 m from land, and 20 m above water level, with her midships gantry crane. The arch collapsed totally and fell partly on the ship, see the photo in my paper. Nobody was injured on board. The ordinary ship radio was destroyed, which delayed contact with the police and the closing of the connecting roads. Meanwhile eight people lost their lives, driving with their motorcars into the water over the edges of the remaining viaducts.

The new bridge was built as a cablestayed steel deck bridge with 366 m free opening and with about 4 m higher level than the old. Especially remarkable is the very short construction time, the new bridge beeing in use 22 months after the accident.

I have to tell you that even this new bridge has been hit by a ship. On the 20th of April 1983 a 16 000 dwt cargo ship passed the bridge. The beam of her loading crane, see fig. 4, was raised to the top and about 20 cm higher than the bridge. The crane beam hit the superstructure, lost it´s topmouth, crashed the railsbeam of the inspection waggon, and then jumped along the underside of the main girder cross the bridge, leaving deep marks in the plate, see fig. 5. The damage is about 250 000 SEK. The accident could have been avoided, by lowering the crane beam.

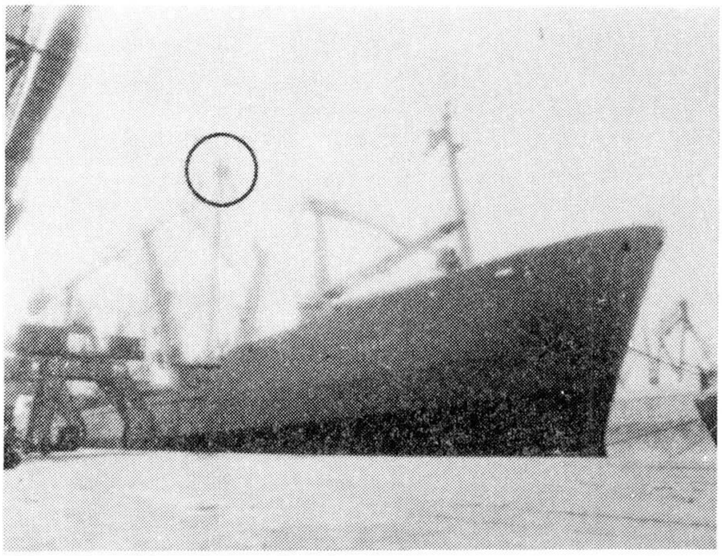

Fig. 4
Colliding crane beam topped O

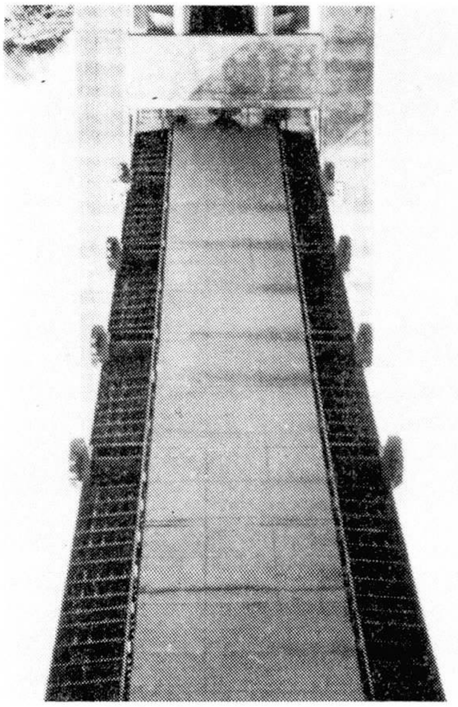

Fig. 5
New Tjörn Bridge. Damage on superstructure under side.

Designing bridges with regard to ship collisions is not yet a fully developed scientific procedure. Nearly all the relevant parameters are rather uncertain. Special measures for increased safety are, on the other hand, normally very costly, as well in the case of a failure, as in the case of design "on the safe side". It seems therefore necessary that the administrator or the authority, who is responsible for planning and maintenance of a bridge across open water, is actively engaged in the final decisions. We must be prepared to take some risks, or many important bridges will never be built.

In the question of risks, our own experience indicates a frequency of $1{,}25 \cdot 10^{-3}$ a year, that ship collision with damage will happen on our bridges. This is relevant for the bridges built before 1967 and planned without any consideration of the ship-collision aspect. It includes all collisions, even if the damage was little. The frequency mentioned might be reduced to half the value, if only collisions with serious consequences are included, but it is still relatively large.

A risk level, in figures, is not known yet. Let me underline, that practically all building - and bridge structures hitherto have been designed after a deterministic approach.

I cannot give you much material for a statistical approach to the problem.

Until internationally generally accepted rules have been found, an individual design code must be settled for each bridge, including figures regarding shipsize, speed, impact angle, forces, movements, method of calculation, safety and risk levels, navigational restrictions, other protective measures as fenders, piers, islands, etc.

Discussion by: Mr. G. Woisin, Private Consultant, F.R.G.

I want to put two questions to Mr. von Olnhausen.

1. Figure 6 represents the Swedish rules for the relationship of collision force and water depth as stated for the planned Øresund bridge already in 1965, while figure 7 shows the Nordic Recommendations of 1975 also reproduced in the papers given by Mr. Tambs-Lyche, Dr. Rasmussen, and Dr. Fjeld. I derive from comparison a strong decrease of the assumed impact forces of 50 to 80% in the area of a water depth of 6 m and a smaller decrease of 10 to 40% in that of 11 m. I would like to ask in which way the smaller 'statical loads of figure 7 have been derived from the kinetic or dynamic loads of figure 6.

2. Why is it assumed in section 3.1 that all bridges with a navigation-channel used by ships of 500 dwt or less are regarded as safe' in any case without regarding resistance to possible impact forces? I refer in this connection to Mr. Frandsen's compilation of 22 severe collisions to bridges containing 12 cases with tugs, barges, etc.

Answer by: Mr. W. von Olnhausen.

1. The design rules for the Oresund project take into account, for the main piers at 11 m water depth, the maximum collision force of 150 MN, corresponding to head-on collision of a 40 000 dwt tanker. For other piers the proposal states 2/3 of the main piers. For all piers and water depth linear interpolation to about 10 MN ice pressure has been chosen.

The Nordic Regulations start from curves for the collision forces, calculated in two points for a 5 900 dwt and a 40 000 dwt ship at various speed (energies) from ref. /2/ in my paper. The curves are then adjusted with regard to the possibility that big ships can go unloaded in shallow water, giving greater collision forces than smaller ships at the same energy. For this reason the calculated forces are raised by 10 MN at 6000 dwt (about 7 m depth). The lower curve, valid for 5 knots speed, is also raised at 40 000 dwt (about 11 m depth) by 30 MN in order to cover the possibility of broad-side collisions, which can give greater collision forces than a head-on collision at that speed.

It is not intended to develop values in the Nordic-regulations diagram from the Oresund-diagram.

2. Mr. Woisin is right, that 500 dwt ships can be dangerous for superstructures - all ships are dangerous for them - and for bridges with substructures of weak piles. All the bridges mentioned by Mr. Frandsen as damaged by tugs and barges are of that type. In Sweden we have not any bridge over a navigational channel of that type. Normally our piers are fairly heavy, so we believe they can withstand about 200 t collision force, corresponding to a 500 dwt vessel. We are aware that this must be checked, bridge for bridge.