fib CEB•FIP Croatian Member Group

SYMPOSIUM DUBROVNIK 2007

Concrete Structures -
- Stimulators Of Development

Dubrovnik | Croatia | 20-23 May 2007

Topic 1: Concrete structures connecting mainland and islands - bridges

PAŠMAN BRIDGE DESIGN

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Key words: Island, crossing, connection, multi-span, box girder, cable stayed

Abstract: *Croatia has recently completed one of the largest motorway projects in this part of the Europe and is continuing to establish fixed traffic links to its distant and underdeveloped parts. The Adriatic sea along the Croatian coast abound with many attractive islands with economic potentials which can be exploited if infrastructure is established. Therefore it is in the national interest to create fixed road links to these islands. Several large scale projects of this kind are currently under way and one of them is the bridge for the Pašman Island. In this paper, alternative bridge solutions for this bridge are presented.*

1. HISTORY OF THE PROJECT

Croatia has about 1185 islands and therefore the State Parliament adopted the National island development program to instigate their revitalization and population. The island infrastructure can only be developed if fixed road links from the coast are established. Because the island of Pašman is one of the closest, a project for a fixed road crossing to this island was the first to be addressed to. It should be noted that the idea for this connection existed for already about forty years. It was professor Kruno Tonković who first developed some bridge alternatives (Figure 1). The sea traffic in this area must not be impaired. The first of his proposals considers a very high bridge with a relatively steep grade line of 2%. Although the clearance for the sea traffic is adequate, piers are high thus extending the bridge length. To shorten this length he considered an even steeper grade line with an inclination of 6% in the area of the sea traffic clearance, but this posed more restrictions for the road traffic on the bridge. A crossing with the underwater tunnel faced the same problem of 2% inclination. As the sea traffic is not so heavy, a moveable bridge was the solution to which professor Tonković devoted most attention and considered different alternatives for moveable parts. As for the location of the bridge his idea was to utilize mid islands Komornik and Babac as a link so that the total bridge length of about 2,3 km would be shortened and divided into three parts (Figure 3). So costs of the crossing were reduced and the passage of larger ships was unimpaired. The moveable bridge was to comprise prefabricated concrete slab superstructure and deep concrete pile foundations extending to bridge piers (Figure 2). Two moveable parts of the bridge (between Turanj and Pašman, and between Babac and Pašman) were designed with relatively simple mechanism.

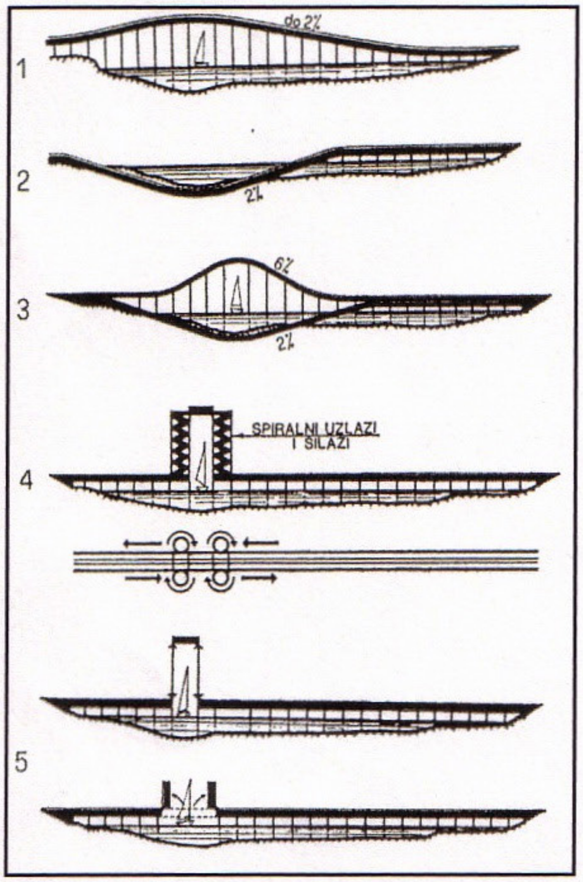

Figure 1: Crossing solutions (Tonković)

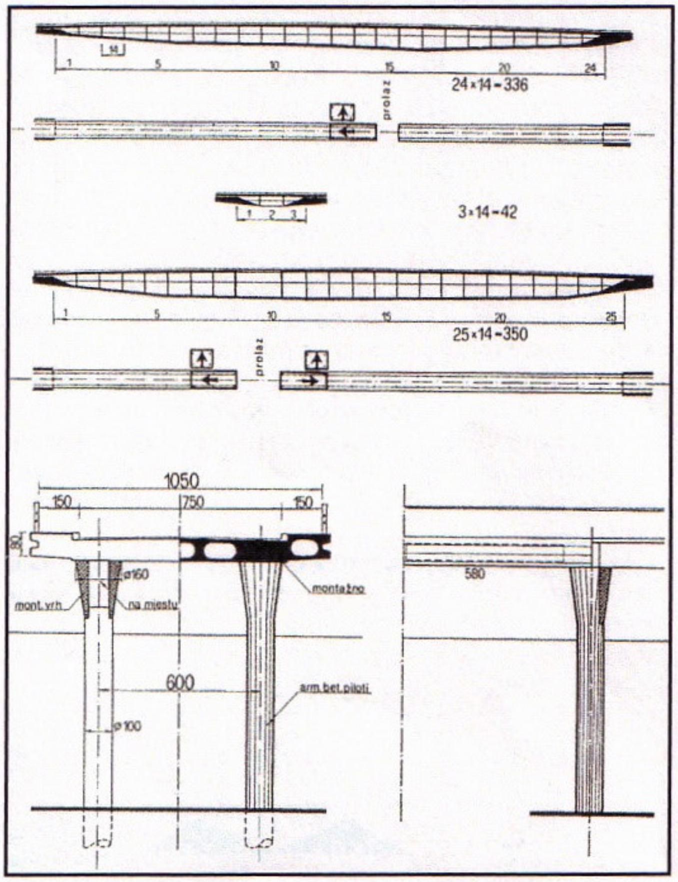

Figure 2: Moveable alternative of the bridge

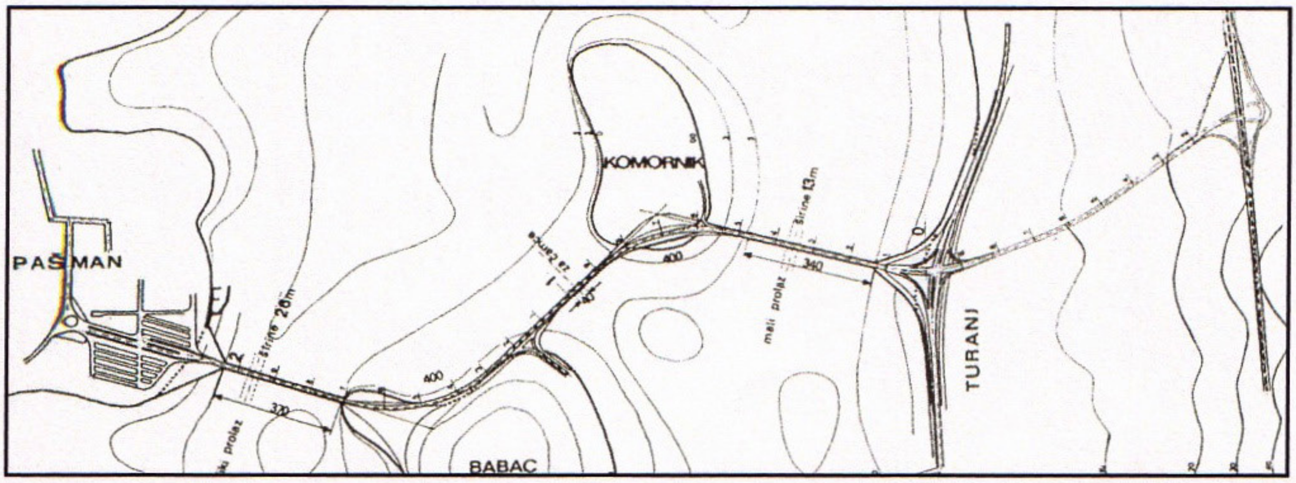

Figure 3: Plan view of the bridge crossing utilizing the two mid islands (Tonković)

2. CURRENT BRIDGE PROPOSALS

In 1997 the Croatian Ministry of the Development and Renewal called for a new preliminary design of the Pašman bridge. By that time an intensive new highway network construction had already started and the Pašman crossing could have been easily incorporated into it. With its strategic position (Figure 4) it would connect most of the mid Dalmatian islands with Zadar and Šibenik and A1 (Zagreb – Split) highway by shortening the ferry routes. Although previous solutions were considered, the new ones had to be done due to the change in sea traffic and planning requirements. First, two water way clearances of 140x40m had to be provided. Secondly, settlements Turanj and Pašman on the islands Komornik and Babac had grown so much that the road to connect the bridges could not be built on that location.

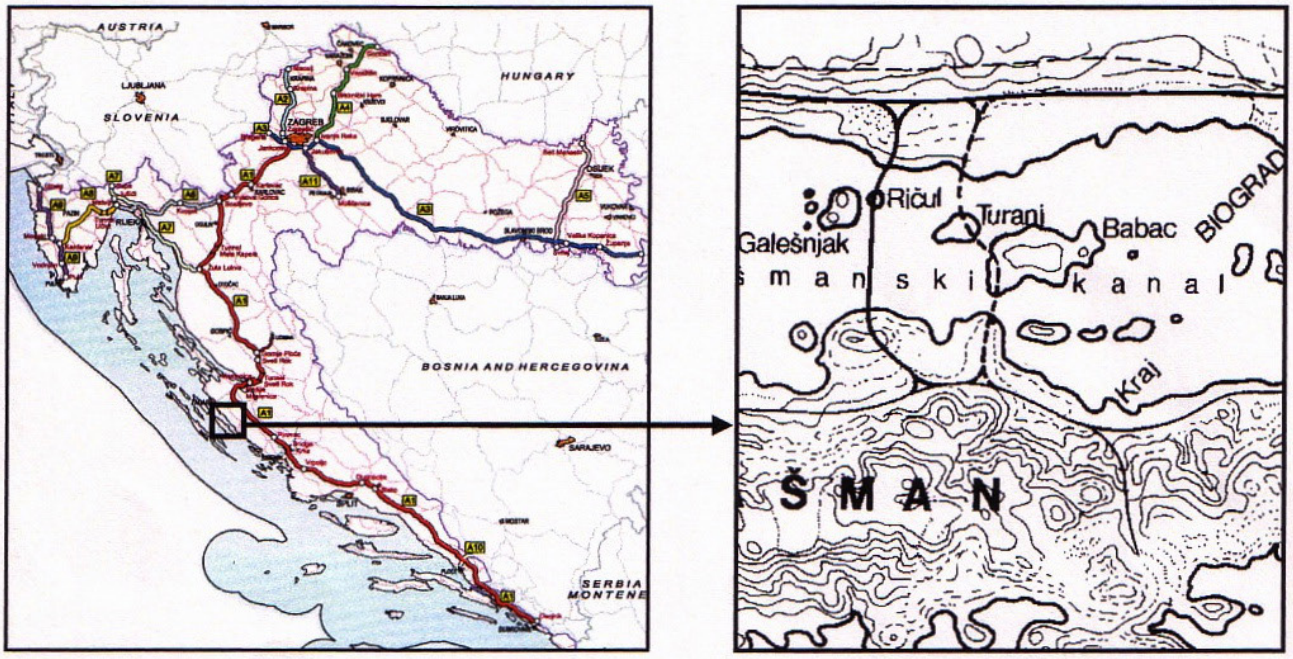

Figure 4: Location of the Pašman crossing in the overall Croatia highway network
New (full line) and the old (dashed line) bridge crossing proposals

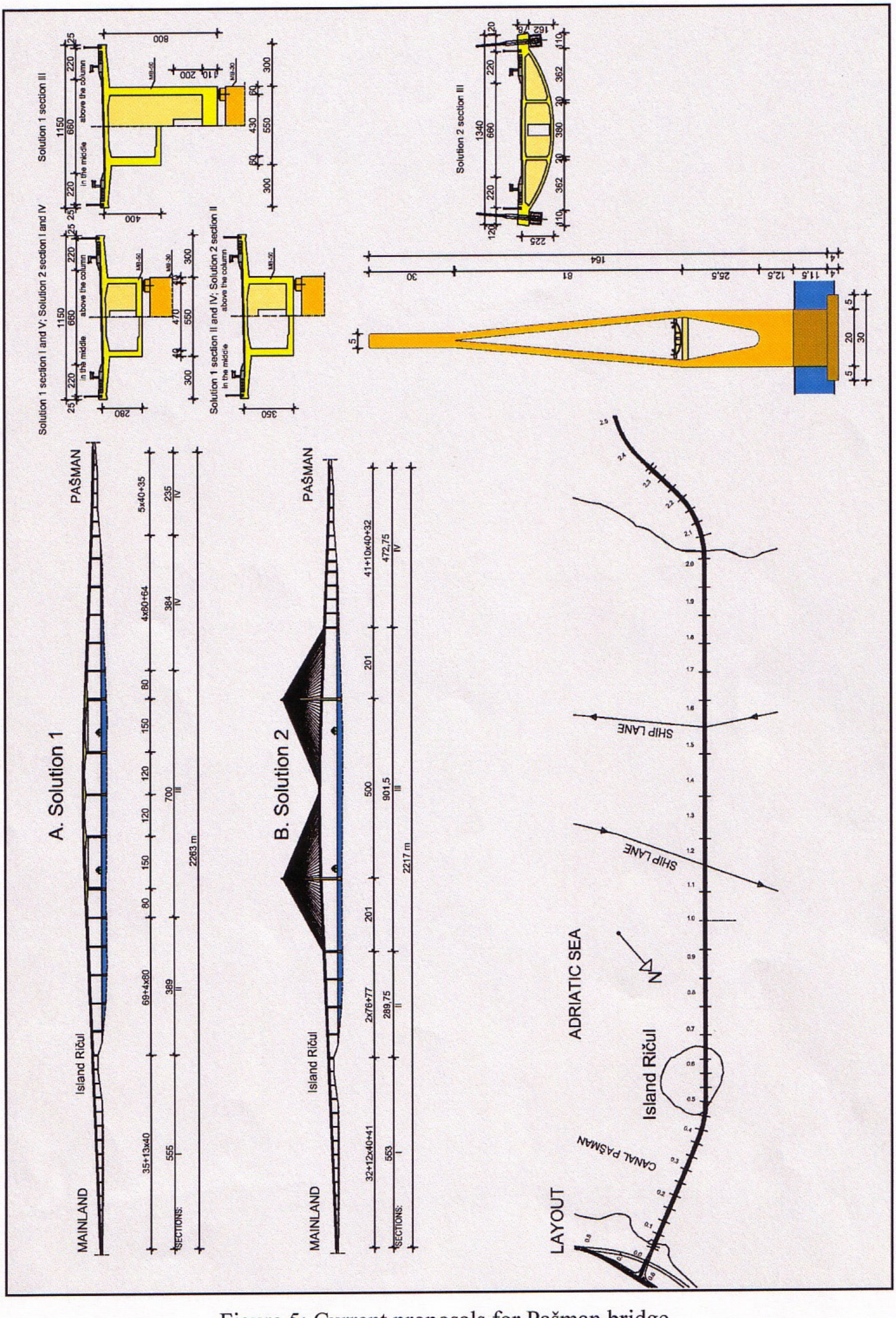

Figure 5: Current proposals for Pašman bridge

A new location was chosen without the utilization of two islands and the bridge crosses over a small Ričul Island (Figure 4). Two new bridge proposals shall be presented (Figure 5). The first alternative is the beam type bridge and the second comprises the main cable stayed bridge flanked on both sides by beam type parts. The carriageway width is 6,6 m and 1,2 m wide footways are provided on each side. The overall bridge width is 11,5 m (or 13,5 in the cable stayed part of alternative 2). Parts of the bridge are straight in ground plan with a horizontal curve between them in section I and a horizontal curve of 250 m radius in the proximity of to the bridge end on the Pašman Island.

2.1 Solution 1 – continuous concrete box girder

Bridge comprises a continuous prestressed concrete box girder superstructure over 36 spans altogether varying from 35 to 150 m (Figure 5.A). The bridge is divided into six sections. The main third section has variable depth superstructure cross-section changing from 4 m to 8 m. Its bottom flange depth varies from 110 to 30 cm and the top flange is 30 cm deep. All other segments are of constant superstructure depth of 2,8 m for sections I and V and 3,5 m for sections II and IV, respectively. The box girder webs are 40 cm thick for sections I and V and 50 cm thick for sections II and IV. Bottom flanges depth varies from 20 cm to 40 cm for sections I and V and from 30 cm to 50 cm for sections II and IV, respectively. Box girders are 5,5 m wide with cantilevers of 3 m on each side. Balanced cantilever erection method is to be used for the spans in the main third segment. The height of 35 box type piers varies from 3 m to 58,5 m. The required sea traffic clearance of 140x40 m is established in the 150 m long spans. The grade line inclination is up to 4,1574% and the vertical grade line curves are R=6.500 m convex and R=6.000m concave. The visualization of this solution can be seen in Figure 6.

2.2 Solution 2 – Cable stayed bridge

The second solution comprises the bridge divided into four sections, where the third one is the main cable stayed bridge (Figure 5.B). Spans vary from 32 to 77 m in the continuous beam type sections and the cable stayed bridge has the main span of 500 m with side spans of 201 m each. The superstructure cross sections in sections I, II and IV are of constant depth, the same as the solution 1. The cross section of the main cable stayed bridge is an aerodynamically shaped concrete box type girder with three cells. It is 2 m wider due to demands on horizontal stability in the much longer main span of 500 m. The depth of this cross section is 2,25 m in the middle with flanges of 25 cm and webs of 30 cm. Cable stays are laterally anchored in the box girder at the pacing of 10 m. In the area of 40 m around the pylon the beam is prestressed. All 30 concrete piers are of box type cross section with constant width of 550 cm, variable 200 cm to 400 cm longitudinal dimension and wall thicknesses of 30 cm. The pier height varies from 8 to 44 m. Underwater foundations are to be made on previously prepared sea bottom. Unsuitable soil will be dug out until solid rock is reached and then replaced with crushed stone aggregate. Precast foundation boxes will then be towed out by boats and placed on the prepared locations. Foundations for pylons can be made in the same way, only if detailed geotechnical investigations confirm it. Diamond shaped pylons of the cable stayed bridge are 164 m high. The pylon box type cross section changes from 10x20m at the bottom to 3,6x5m at the top with 70 cm thick walls. The underwater part of the pylon is filled with concrete. Pylon legs under the superstructure are connected by a transverse beam. The sea traffic clearance is established in the 500 m main span. The grade line inclination is up to 3,58% and the vertical curves are R=6.988m convex and R=6.000m concave. The visualization of this solution is shown in Figure 7.

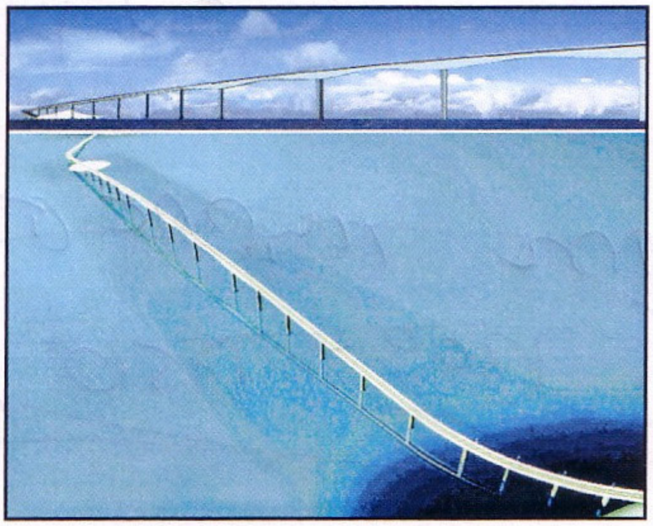

Figure 6: Solution 1 visualization

Figure 7: Solution 2 visualization

3. CONCLUSION

Benefits from the fixed connection of the Pašman Island to the mainland are numerous. Revitalization of Croatian islands is necessary and in the national interest. It will enable new potentials, primarily from tourism, to be exploited. The same living conditions as on the mainland will keep people from emigrating and attract others. It will also bring other outside islands closer to the mainland as the ferry routes shall be shortened. The bridge solution has the technical advantage over a tunnel due to the closeness of the coasts and the considerably shallow water (about 15,5m). In the given solutions all sea traffic demands were satisfied and the bridge does not interfere with the ship routes. It is also advised to make further studies on the sea traffic requirements, as even slightly relaxed clearances would significantly lower the costs of the bridge.

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