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Bridges in Tropical Developing Countries in the South Pacific Area

Ponts dans les régions en voie de développement du Pacifique du Sud

Brückenbau in Entwicklungsgebieten im Südlichen Pazifik

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SUMMARY
Economic, climatic and resource constraints in the construction of bridges in developing countries in the South Pacific Area are described.

RESUME
L'article décrit les contraintes économiques, climatologiques et de resources en relation avec la construction de ponts dans les régions en voie de développement du Pacifique du Sud.

ZUSAMMENFASSUNG
Die wirtschaftlichen und klimatischen Randbedingungen sowie die Probleme bei der Beschaffung der Baustoffe beim Brückenbau in Entwicklungsgebieten im Südlichen Pazifik werden beschrieben.

1. INTRODUCTION

Northern Australia, Papua New Guinea and the adjacent Pacific Islands have a number of common features apart from geographical location. They are all tropical and are undeveloped areas. However within these areas are large variations in climate and in degree of undevelopment. But most important, they all have limited funds for development and all these factors have a material bearing on the appropriate form of bridging.

2. STANDARDS

The establishment of a road network generates a considerable increase in traffic. The dilema is whether to stretch scarce resources on a rudimentary system which will soon be inadequate or build less but better. Bridges are expensive items in any road network and their construction entails special consideration.

It is unlikely that a bridge constructed for expected traffic in the near future will be adequate for traffic in 30 years time, and it is uneconomic to expend extra funds now to cater for an uncertain expectation. On the other hand an absolutely minimum expenditure is short sighted economy. For example: there is a universal demand for increased vehicle loadings and in these areas where railway construction is unlikely there are tremendous pressures to carry bulk materials in heavier vehicles. In small span bridging a 30% increase in live loading may increase the total cost by only 3%. An increase in horizontal forces will have a greater cost effect. So for short spans it is false economy to use low design loadings. In longer spans the increase in cost may be more significant.

Another dilema is whether a single lane, double lanes, or a single lane for later widening on substructure built now for double lanes is warranted. The expected period of time until widening is a major consideration along with foundation costs as money is locked up in unused structure and when the bridge is finally deemed inadequate, reconstruction may be to another standard or the bridge may be wanted in another position.

Double lane bridges have better overload capacities than single lane bridges but cannot be justified on this count alone for very low traffic levels.

3. FLOODS

The region includes some of the wettest areas in the world and some very dry, but in all cases peak flood runoffs are invariably much greater than in temperate climates. Table I showing typical flood runoff figures may illustrate this.

It can be seen that not only are frequent floods of much greater magnitude than in temperate climates, but that in these tropical areas there is sometimes a much greater difference in size between less frequent floods and the more frequent. Thus with limited budgets it is not always possible to

TABLE I

Location	Climate	Flood Runoff-Comparable Catchment (1)	Ratio. 100 year Flood to Mean Annual Flood (2)
Solomon Is. Guadalcanal	Very High Rainfall	300	3
Papua New Guinea (North)	High Rainfall - Low Variability	100	2.7
Papua New Guinea (South)	High Rainfall Variable	90	3
North Australia	Monsoonal	100	6
North Australia	Cyclonic	90	6
Central Australia	Semi Desert	50	5
U.K.	Cool Temperate	20	2.5 (3)
USA Washington State	Cool Temperate	20-30	2.5 (4)

(1) 100 year return flood from 100 sq km (typical values) - m^3/sec.
(2) Q_{100}/Q_2 from 100 sq km
(3) From Nash & Shaw - "River Flood Hydrology" - I.C.E. Lond. 1965
(4) From "Magnitude & Frequency of Floods in the USA" - U.S. Geology Survey 1964.

construct bridges clear of flood waters and the art is to position bridges to obtain the best serviceability in terms of period of inundation on each particular route.

Once the decision is made to build submersible bridges, bed and bank scour, approach road erosion, river flow obstruction, river debris obstruction and buoyancy all become significant design considerations. In certain areas, design to prevent the collection of debris is of paramount importance (Fig. 1,2) and a bridge with deck level at a height at which a flood persists will cause more difficulty than a lower one over which the rising flood clears debris. The immersed structure must be shaped not to entrap debris, or if above flood, the spans long enough to clear the expected debris size (Fig.3).

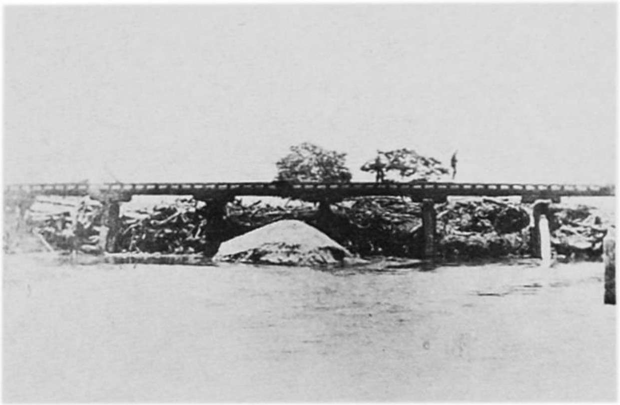

Figure 1
Spans too small

4. TEMPERATURE

Temperature range in parts of the wet tropics is small allowing a reduction in the frequency of expansion joints with consequent benefits to cost and earthquake resistance.

Figure 2
Spans too small
Deck at flood peak

In semi-desert areas the range is considerable and joint detailing and bridge articulation is critical. Elements such as approach slabs need to be anchored to the bridge to prevent incremental "walking" off the bridge.

5. MATERIALS

All steel is imported and containerisation of shipping has placed a further restriction on the transport of long items.

Figure 3
End scour after waterway blockage.

Cement must also be imported and is of varying quality depending on origin and age. Concrete aggregates from desert areas have to be checked for alkali reactivity and placing concrete in extreme hot and dry or continuously wet conditions requires special techniques.

Where possible, it is desirable to employ local materials, and some timbers are suitable for bridges. In very wet climates fungal deterioration increases maintenance costs and in Australia, precautions have to be taken against termite attack. Nevertheless, the use of local timber may provide a short to medium term bridge until traffic warrants reconstruction. (Fig.4)

Figure 4
Submersible bridge replacing lower timber bridge

6. LABOUR & EQUIPMENT RESOURCES

The labour force ranges from highly experienced and competent in North Australia, to uneven standards in the islands Large equipment is not present and if introduced may not be able to be readily transported to the construction site. Design needs to take cognisance of these factors.

Figure 5

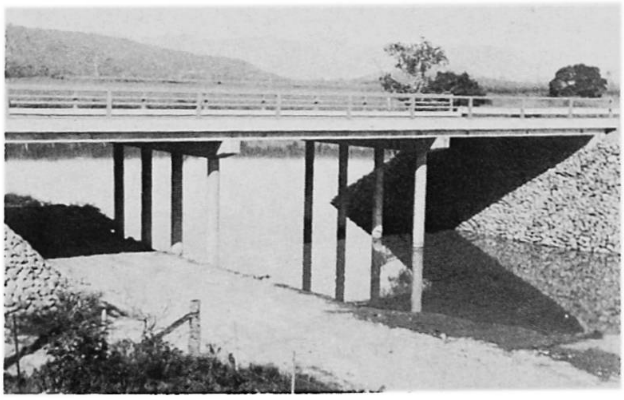

Figure 6

7. CONCLUSION

The type of bridge that results is frequently a small span (6-20m) reinforced cast insitu concrete slab; or a deck of prestressed concrete precast slabs (Fig.5,6) or a composite reinforced concrete deck with plated universal beam girders. Piers are frequently headstocks on steel or reinforced concrete piles or reinforced concrete columns. Geometric complications are avoided, and site construction details are as simple as possible.

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