12 LOAD CARRYING CAPACITY

12.1 GENERAL

Criteria for evaluating the load-carrying capacity of a bridge for either normal (legal) live loads or overweight loads under permit, are contained in the Transit New Zealand "Bridge Manual" (SP/M/014), and this section offers some comments on that document.

Such evaluation needs to be preceded by an inspection to determine any significant features that might affect the result. Inspection will normally concentrate on superstructure members as they are usually critical for live load, but the possibility of others being critical should not be neglected. Some possibilities are timber piles, foundations affected by scour, deteriorated bearings and support members badly cracked or showing reinforcement corrosion.

The evaluation process consists of determining the working load capacity of critical members for either normal live load or overload as appropriate. Comparison of the capacities with standard loading at both levels leads to parameters for Posting (for live load) and Rating (for overload) which are used to characterise the load capacity of the bridge.

Evaluation of the load-carrying capacity of a bridge should be certified by a Registered Engineer.

12.2 IMPACT FACTORS

The impact allowance is a significant proportion of the live load effect, and the "Bridge Manual" allows for a measured value to be used if there is reason to believe that the design value is not representative. This could be of significant advantage in some cases. If impact is to be measured, the work should be done by experienced laboratory staff.

12.3 MATERIAL STRENGTH

The "Bridge Manual" gives nominal strengths for materials of various ages, but allows use of measured values if required.

12.3.1 Concrete

In most reinforced concrete members, where flexure is critical, the exact concrete strength is not of real significance because both shear and moment strength are in practice governed by the reinforcement-yield value. It will therefore not often be necessary to obtain measured values. However, it may be worthwhile if any of the following are critical:

- Reinforced concrete columns;
- Reinforced concrete arches;
- Reinforced concrete continuous beams, for negative moment.

For prestressed concrete members, strength may be critical, but it is likely that in most cases there will be better records of design and/or test values.

12.3.2 Reinforcing Steel

Historically, steel strengths have been quite variable so the nominal values are likely to be conservative in most cases. It is usually well worthwhile to obtain yield strengths, and this can be done from measurements of steel hardness. Various instruments are available to do this non-destructively, and it is advisable to obtain the services of a testing laboratory. It is of course necessary to remove some cover concrete to perform the testing.

If measured strength is exceptionally high, the requirement of 6.4.4(a) of the "Bridge Manual" should be noted to guard against compressive concrete failure.

Where corrosion of the reinforcement is suspected, investigation of the reinforcement's condition should be undertaken. This will involve exposure of the reinforcement at critical sections, and at sections at which corrosion is likely to be most pronounced as evidenced by cracking and spalling of the cover concrete, to enable measurement of the remaining steel section to be undertaken.

12.3.3 Prestressing Steel

Accurate knowledge of the strength of prestressing steel is not usually required because the effective force in the tendons is of more significance. There is at present no practical way of measuring prestressing steel strength non-destructively, so reliance must be placed on existing records, or on values from standard specifications.

12.3.4 Structural Steel

The statement on reinforcing steel applies essentially to structural steel.

12.3.5 Timber

If identification of the species of timber is required, the services of the Forest Research Institute, Private Bag 3020, Rotorua, or other specialists may be obtained.

12.3.6 Analysis of Test Results

Where strengths are measured, the "Bridge Manual" requires an adequate number of test results to give statistically reliable values. It should be noted that the reliable value increases rapidly with the number of tests, where this number is small (see Table 6.2 of the "Bridge Manual").

12.4 MAIN MEMBER CAPACITY AND EVALUATION

The majority of bridges consist of a simple span beam system, in which the critical section is likely to be at midspan. However, the possibility of an unusual arrangement of curtailed reinforcement or steel cover plates, or an unusual prestressing cable layout could make other sections critical. Shear design has generally been more conservative than flexure, so it is usually safe to assume that end shear will not be more critical than bending in undamaged beams. In situations where shear capacity is critical, measurement of concrete strength can be worthwhile. By similar reasoning, diaphragms are not normally critical if undamaged. In order to determine the load distribution between beams, a grid analysis is usually the most appropriate method.

In a system other than simple spans, it may be more difficult to identify critical sections, and a computer grid analysis may be required for this reason as well as to determine load distribution between beams.

In the case of timber bridges, some experience is desirable, and problems are discussed in "Strength and Durability of Timber Bridges" (RRU 1989).

12.5 DECK CAPACITY AND EVALUATION

Concrete deck panels with all edges relatively rigidly supported and restrained by girders and adjacent deck panels, resist loading primarily by membrane arch action and tend to fail in a punching shear mode.

Not all slab panels meet the requirements to enable them to be considered as acting in membrane arch action. Where conventional elastic analysis has been used to rate deck slabs, it has been found that, in the majority of reinforced concrete decks on longitudinal beams, either transverse negative reinforcement or longitudinal positive reinforcement is critical, but the possibility of other sections requiring consideration should not be forgotten.

Where deck slabs exhibit extensive cracking, the cracks should be marked and their growth monitored over time. Load testing offers a method for assessing the deterioration of the deck slab panels and of monitoring the ongoing progressive deterioration of the deck slab over time, as discussed in "Fatigue Life of RC Bridge Decks" (McCarten, 1991).

12.6 PROOF LOADING

Proof loading is sometimes useful to verify theoretical findings, especially in cases where it is difficult to model the structure adequately for computer analysis. Criteria are laid down in the "Bridge Manual". If proof loading is contemplated, the services of an experienced laboratory should be obtained.

12.7 MITIGATING RISKS POSED BY WEAK BRIDGES

Options for reducing risks posed by weak bridges, until such time as they can be strengthened or replaced, include the following:

- Imposition of a speed restriction;
- Imposition of vehicle gross weight and/or axle weight restrictions;
- Limiting the number of heavy motor vehicles permitted on the bridge at the same time;
- Closing the bridge to heavy motor vehicles and rerouting the heavy motor vehicles around a bypass, e.g. via an adjacent ford through a stream.

12.8 BIBLIOGRAPHY

RRU (1989): "Strength and Durability of Timber Bridges". Bulletin 80, Road Research Unit, Transit New Zealand, Wellington.

Transit New Zealand (1994): "Bridge Manual" (and amendments). Transit New Zealand SP/M/014.

McCarten P. S. (1991): "Fatigue Life of RC Bridge Decks". Proceedings of the 8th Annual International Bridge Conference, Pittsburgh, Pennsylvania.