

for roads. For that purpose, some of the bridges seem to be required to elevate the level of functions, which leads to the consideration on necessity of rehabilitation with strengthening of function or replacement.

With regard to the rehabilitation designs of 10 bridges selected for detailed inspection, they are intended to demonstrate the basic ideas and examples of rehabilitation designs, with the main purpose of restoring their original structural functions, and therefore not worked out based on structural calculations. Also, although geological surveys of the bridge foundation was attempted for the bridges where it was considered necessary, they were conducted only to a practically possible point per bridge, instead of proper positions near the bridge piers, they seems to be insufficient to grasp the excavation depth of foundation, for correct designs of the sub-structure rehabilitation. Therefore, at time of implementation of the substantial rehabilitation works of the foundation, it is recommended that the design works shall be done based on additional detailed surveys and investigations.

Also, there are some bridges inspected in details which are identified to require certain sorts of proper structural improvement and/or have been inadequately rehabilitated before by improper methods. Furthermore, some bridges are found to have barely enough structural strength, but with fairly great deformation inducing transverse vibration or rolling which are causing anxiety to the road users, and need constant observation and investigation in the future (Malleco). Also, some are found to have been severely deformed (Amolanas). With these facts in consideration, it is recommended that the design concept and standards would be reviewed and revised to be established as the national standards so that they properly conform to future requirements to strength and measures to deformation as well as to the structural details which can not be defined by just the design calculation.

## **(2) Guideline for Bridge Maintenance Inspection**

The guideline for bridge maintenance inspection prepared in the Study is intended as a reference or a specimen to those engineers who are engaging in the bridge inspection works. It describes not only the key points of bridge inspection upon its execution, but also the fundamentals of bridge maintenance, such as the evaluation method of bridge defect and standardized bridge rehabilitation method. However, it does not cover the inspection of wooden, Fink and suspension bridges and other types which are widely located on the local roads in the country, because the Study is for the bridges on the National Route 5.

The guideline is also recommended to be revised and improved with additions and/or modifications in the course of actual utilization, and to be made as a proper manual for bridge maintenance inspection and rehabilitation. For this purpose, periodic monitoring from the field engineers will be recommendable.

## **(3) Bridge Maintenance Management System**

For practical and economical adoption, a bridge maintenance management system with a micro-computer was developed which has the data-base on various bridge dimensions and records of inspection to determine the defect degrees of bridges. This system was expanded to include the sub-systems to calculate the rehabilitation costs

and to determine the priority which are the supporting tools for formulation of the bridge rehabilitation plan.

Formulation of the optimum organization structure and operational standard for bridge maintenance and determination of the most effective budget allocation for this purpose involve very complicated and difficult issues. These complication and difficulty are attributable to the fact that because of the reason that a bridge is a part of the road, there are so many factors to decide a certain measure to the bridge, such as political consideration, regional development aspect and budgetary constraint, in addition to purely engineering requirement. Therefore, the system was so developed as to provide the road administrator with many different indicators for decision making.

However, any system can not be a complete and established system at the time of its initial development. The system should be further improved for easier, wider and dependable applications in the future through practical and continuous utilization. In order that the Chilean engineers can realize such system improvement, it is vital to facilitate the transfer of technology.

## 9-2 Recommendation

(1) For formulation of a bridge rehabilitation plan, it would be one of the important factors to consider approaches to the national development policies and strategies on infrastructure and related socioeconomic sectors, normally stipulated in respective national plans. However, the plan drawn out and proposed in the Study does not include such approaches.

Apart from this concept, up to present the actual practice of the bridge maintenance in this country has been obliged to execute on the ad-hoc basis as an emergency measure for those bridges which have been facing critical problems and have needed immediate remedial works, because of the very severe constraint on financial resources for public expenditure. However, it is considered necessary to work out the bridge rehabilitation plan from now on, at least within the frame-work and closely coordinated with the road rehabilitation plan.

For implementation of the rehabilitation works, causes of defects and deformations of the bridges shall be identified by means of the recording and analysis of the periodical changes obtained by consecutive and sequential measurements and inspections. To this end, a proper filing system shall be established to keep and store the design documents, preferably those at bridge completion, and the records of periodic and other inspections, etc. having proper data up-dating mechanism.

## (2) Application of Bridge Maintenance Management System

For effective and efficient utilization and application of the proposed bridge maintenance management system, recruitment of the personnel well versed both in computer system as well as bridge engineering is recommended. But to master the required expertise in a short period would be impossible, and therefore, intensive and extensive technical training by the Japanese expert(s) would be necessary for a certain length of time through the technical cooperation program.

### (3) Organizational Structure for Bridge Maintenance

At present there is a department of roads in each regional office of the Ministry of Public Works (MOP), and this department is responsible for maintenance of the bridges and other road structures. In order that the existing organizational structure will be able to produce very high administrative and work efficiencies, standard operating procedures for proper bridge maintenance shall be established and prevailed to all the offices of the MOP.

Also, with assignment of clear-cut missions, authorities and responsibilities, along with provisions of the guideline for bridge maintenance inspections and related instruments, tools and materials, existing organization the MOP will be able to improve better administrative performance.

The bridge inspection and related maintenance activities are to be conducted by each regional department of roads in accordance with the standard operating procedures, the outline which can be described as follows.

- 1) Bridge inspections are to be carried out by the engineers in charge of the roads department of the MOP regional office. The original of the inspection record shall be kept at this department, and a copy of the record with comments shall be sent to the MOP headquarters
- 2) At the MOP headquarters, the copy will be used as an input data sheet to the bridge maintenance management system in which the data are stored and updated as a comprehensive and integrated data-base of all the bridges. With the data-base the MOP headquarters will formulate the master plan and various plans of action for bridge maintenance and related rehabilitation with indication of required budget, for which an organizational unit will be required to be set up. It is earnestly hoped that when the computer network systems are developed and established with on-line access between the headquarters and the regional offices of the MOP, existing organizational structure will be reviewed and be reorganized for the better structure and performance.







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