ROAD BRIDGES AND OTHER STRUCTURES

Thursday 23 October 2003 (1.30 – 5.00 p.m.)

SESSION AGENDA & INTRODUCTORY REPORT

22.11.E

SESSION AGENDA

Opening

Ms. Brigitte MAHUT (C11 Chairperson/FRANCE)

PART 1: Presentation of the work done by C11

1. **Structure as components of the infrastructure**

   Mr. John BJERRUM (C11 member/DENMARK)
   Ms. Sussane TROIVE (C11 member/SWEDEN)

2. **Management tools and organization**

   Mr. Tore LJUNGGREN (C11 member/NORWAY)
   Mr. Børre STENVOLD (Norwegian Public Road Administration/NORWAY)

3. **Economic approach**

   Mr. Gérard DELFOSSE (C11 member/FRANCE)

4. **Technical criteria**

   Mr. George ROMACK (C11 member/USA)

5. **A survey on Rehabilitation Actions**

   Dr. Hiroshi SATO (C11 member/JAPAN)

PART 2: Presentations from invited speakers

1. **Bridge management in Madagascar**

Ms. Celestine RAZANAMAHEFA
(Ministry of Transport, Public works and Territory development/MADAGASCAR)

2. **A South African perspective on bridge management and some unique problems encountered**

Mr. Edwin KRUGER (C11 member/SOUTH AFRICA)

3. **Future Topics**

Mr. Michel DONZEL (C11 French-speaking Secretary/SWITZERLAND)

CONTENTS

EXECUTIVE SUMMARY

Bridges are key element of the road network and represent important national asset to the government. Maintaining serviceability of bridges and consequently retaining their level of reliability during their lifetime deserves high priority from technical and socio-economic considerations. Many of the bridges mostly constructed during the 1960's and 1970's are now in need of repairs or no longer can adequately serve the road user. Growth in road traffic and increase in truck weights in the second half of the 20th century has been remarkable. The need for safe, effective bridge maintenance and repair to maintain reliable highway is increasingly urgent worldwide.

To serve as a tool to be used in allocating limited resources effectively to the inspection, maintenance, rehabilitation and replacement of bridges, bridge management systems (BMS) have been developed by many countries. The committee C11 has studied this issue from the management, socio-economic and technical viewpoints. Proper management of bridges needs an integrated set of procedures for directing and controlling all activities related to bridges. The key element is to have a suitable database, appropriate tools for assessing bridge needs, integrated decisions and activities related to the above mentioned activities with the standpoint of long term period.

This Report introduces the topics to be presented and discussed at the Congress Session organized by Committee C11 - Road Bridges and Other Structures. It is hoped that those who intend to attend the session will find it useful reference for preparing their contributions to the discussions.

The programme for the session has been organized so that, following a description of the work on bridge management carried out by the committee during the preceding four years, completed by some contributions from different countries, the discussion will concentrate on future important topics in the area of bridge engineering and management.

- Presentation of the work carried out by C11 in the field of bridge management :
  - Bridges, as a part of the infrastructure
  - Organization and tools for the management
  - Economical approach
  - Technical criteria
- Contributions from invited speakers :
  - Bridge Management in Madagascar
  - A South African perspective on bridge management and some unique problems encountered
- Future topics : general discussion

1 - INTRODUCTION

Bridges are key element of the road network and represent important national asset to the government. Maintaining serviceability of bridges and consequently retaining their level of reliability during their lifetime deserves high priority from technical and socio-economic considerations. Many of the bridges mostly constructed during the 1960's and 1970's are now in need of repairs or no longer can adequately serve the road user. Growth in road traffic and increase in truck weights in the second half of the 20th century has been remarkable. The need for safe, effective bridge maintenance and repair to maintain reliable highway is increasingly urgent worldwide.

To serve as a tool to be used in allocating limited resources effectively to the inspection, maintenance, rehabilitation and replacement of bridges, bridge management systems (BMS) have been developed by many countries. The committee C11 has studied this issue from the management, socio-economic and technical viewpoints. Proper management of bridges needs an integrated set of procedures for directing and controlling all activities related to bridges. The key element is to have a suitable database, appropriate tools for assessing bridge needs, integrated decisions and activities related to the above mentioned activities with the standpoint of long term period.

Some of highway agencies are researching and evaluating an asset management approach to their many physical items they own and for which they are responsible. In the committee C11, asset management has been studied in relation to bridge management looking at benchmarking bridge management activities. In addition, user costs and benefits including whole life costing have been examined as well. Also from the technical view point the assessment of structure condition was studied.

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The following programme for the session has been organized, and the discussion will concentrate on future important topics in the area of bridge engineering and management.

Presentation of the programme of the Session C11

This session is intended for decision-makers, road owners, engineers and authorities in charge of bridge management. It will place emphasis on the need for a well-structured organization and the benefit of a technico-economic approach for an optimal use of resources allocated to bridge assessment and maintenance.

Presentation on bridge management studied by C11

The first part of the session will focus on the following main topics:

- Structures as components of the infrastructure
  Why and how implement a coordinated management of all components of road assets, i.e. roads, bridges, walls, etc.

- Management tools and organization
  The presentation of the results of a comparative study of various Bridge Management Systems will provide useful information to any country wishing to implement a bridge management system or progress the existing one.

- Economic approach
  An approach where the management will no longer be based on technical criteria only, is discussed taking account of users and whole life cycle costs. How can the Whole Life Costing approach be applied to bridges?

- Technical criteria
  Performance indicators for structures and criteria to define priorities in maintenance and repair, and based on the responses from member countries practical rehabilitation actions of concrete bridges with necessary research and development are introduced.

Moreover, the session will aim at highlighting the expectations and needs of bridge owners and managers, based on experiences reported by the experts related to management of bridges.

Contributions from invited speakers

The purpose of these contributions is to illustrate how these countries have define their bridge management policy, the organization and the tools implemented, the difficulties encountered, the future developments expected and their perspectives

- Bridge Management in Madagascar
- A South African perspective on bridge management and some unique problems encountered

Future topics

The session will end with a general discussion in order to identify future topics to be treated by PIARC C11.

2 - PROBLEMS ON THE MANAGEMENT OF BRIDGES

2.1 Current situation in Asian and Australasian countries

Many highway authorities have been confronted with urgent and important issues on management of bridges. This can be seen, for example, in the following summary of 15 responses from Asian and Australian countries on the confronted problems and difficulties on bridge management, for the seminar "Management of Road Bridges in Asian Countries" in Bangkok on June 2002. Even though this may not cover whole problems confronted, the general outline for the problems can be given in a broad sense.

2.1.1 Budget

- Amount
- Appropriate allocation

In a general way, road authorities in many countries deplore lack of funds for maintenance of bridges. The managers in charge are facing to decision-makers that need evidence to justify the demand. They must explain the collective utility of the funds, especially in comparison with other public choices.

The objective is not to increase the bridge quality over what is necessary, but to maintain the asset at a predefine level. Many times, the problem is more to have a good allocation and use of funds than the absolute amount of funds.

It is necessary to build good indicators in order to evaluate the use of funds, and efficiency of the strategies conducting to reach the objectives and targets of the policy.

Those indicators must take in account:

- Technical aspects: maintain or improvement of the level of service, durability, possibility to adapt the characteristics of the structure to future functional needs

- Social-economic aspects: traffic safety, user cost, environmental impact etc.

The continuous increase of the structure stock and its aging make asset management more and more difficult. In addition, growth of traffic, as in volume than in number (heavy loads aggressiveness, increase of maximum authorised loads, maximum axle authorized load, fatigue) has been remarkable.

2.1.2 Organization and Personnel

- Organization
- Human resources dedicated to existing bridges/new bridges
- Number and skill of personnel at different levels

Policy definition must be conducted with preliminary thought on possible organizations regarding human resources.

2.1.3 Technical Resources

- Basic means for inspection (e.g. vehicles, survey equipments)

- Technical tools for inspection (e.g. methods easy to use on site for evaluate the condition, non-destructive test (NDT)).

It is clear that without a minimum of equipment or financial means for calling consultants, it is impossible to ensure the minimum control of the structure. In this case, it is not possible to speak about survey policy. Now, there is a major demand for non-destructive investigation means, easy to use, and giving a reliable estimation parameters to appropriate the condition of the bridge.

2.1.4 Other Technical Problems

- Works under traffic
- Justification of existing bridges vs. current standards

Works under traffic is very serious problem, especially when it is difficult to detour the traffic or in urban area. More and more, owners and road users do not accept trouble due to traffic jam, delay, local safety decrease.

Few countries have special rules about the needs of compliance of existing bridges.

2.1.5 Bridge Management Tools

- Software
- Link with road management (e.g. GIS)

The choice of the software must be conditioned by the methodology, previously defined, and not the opposite. Geographic system of information (GIS) could be a very important tool to coordinate works and minimize the disturbance to users on a route. For example, by applying GIS it can be socially and economically proper practice to change the expansion joints and removal pavement at the same time, even if it was not yet imposed by the condition of this expansion joint.

2.2 Current situation in African countries

The conclusions of the same inquiry in African countries (7 answers) highlight the same type of difficulties:

- lack of funding,
- lack of human resources, and specifically of skilled and trained people,

- lack of tools and devices (for example : survey vehicle),
- the age and condition of the stock of bridges : presence of decayed bridges with lack of maintenance in the past,
- problem of heavy traffic loads,
- design code.

Two countries from Africa (Madagascar and South Africa) have been invited to make a presentation in Durban in order to illustrate the situation of bridge management and perspectives (see § 4).

3 - BRIDGE MANAGEMENT SYSTEM - THE TOPIC STUDIED BY C11

The important issues of the Committee 11 have been mainly defined to meet the goals of PIARC Strategic Plan, Topic Area 4 - Management and Administration of Road System. Specifically these topic areas referenced to this effort are:

4.1 Developing, improving and implementing asset management processes

4.2 Management and technology systems within an integrated transport system
4.4 Effective coordination between network managers, operators and the community

4.5 Making more efficient use of the road budget
4.8 Organizational structure and effective performance management within road administrations

To exchange information among countries and to highlight best practice, the committee, in accordance with the aim of the strategic plan chose the following three study topics on the current status of bridge management systems used and performance measures employed. The three topics relied primarily on the results of preliminary and complementary questionnaire, sent to members of the committee.

1. Asset management
   - Asset management in relation to bridge management
   - Comparative study on bridge management activities
   - Repair of bridges under traffic

2. Performance management
   - Towards a performance management of bridges
   - Bridge management : Results of surveys in Asian and Australasian countries, and in African countries

3. Bridge and structure conditions
   - Indicators for bridge performance and prioritization of bridge actions

   - Rehabilitation actions of concrete bridges

3.1 Asset Management

3.1.1 Asset Management in relation to Bridge Management

The basic ideas/philosophies behind already developed asset management systems and systems under development and the exchange of data between asset management systems and bridge management systems have been studied. Asset management systems in this context include the overall management of all the road assets: pavement, bridges, tunnels and road furniture (guard-rails, signs, lightning etc) and other assets within the road/bridge administration, e.g.: construction and maintenance equipment, real estate and human resources.

There is no worldwide official unambiguous definition of AM-systems. But OECD's Expert Group on Asset Management Systems (IM1) and FHWA, Office of Asset Management of the United States have been dealing with this matter for some time and have more or less set the standard or approach for development of AM-systems. Therefore, in general, the study follows the work of OECD and FHWA and the components of an AM system appear from Figure 1.

The objectives for implementing an AM-system are mainly a demand for most cost-effective management of the infrastructure network with reduced human resources, and a greater focus on safety and user satisfaction. To reach the objectives, the process and organization is very important.

The Asset Management system is generally based on an integration of existing management systems for different assets. The existing management systems are then complemented with components for performance modelling, priority-ranking, project selection, or anything else that may be necessary. The data exchange between the AM-systems and the BM systems includes some basic inventory data: location, size/extent, type/material, age, and in some cases: the value of the bridges, data on hydraulics, load limit, cost and repair history, traffic information along the road and traffic volume.

The data on condition assessment and other preconditions that have been reported to be exchanged between AM and BM systems are:

- damage description,
- condition mark,
- maintenance/repair description,
- maintenance/repair cost.

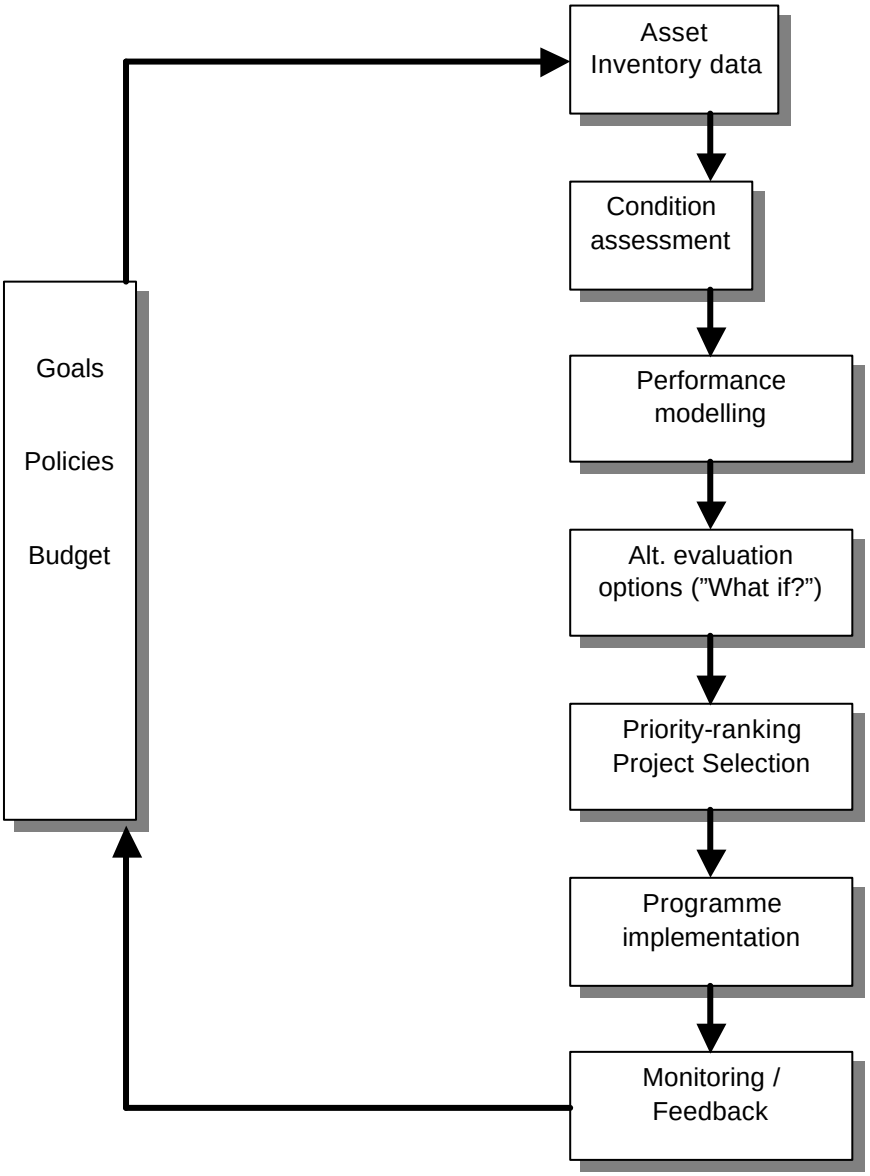

Figure 1 - Components included in the study of Asset Management

3.1.2 Comparative Study on Bridge Management Activities

The purpose of the study was to compare the performance of the most essential Bridge Management (BM) activities in all C11 member countries. The activities in question includes:

- Inventory
- Inspection (5 different types, including condition evaluation and damage assessment)
- Priority-ranking of works
- Carrying out operation, preventive maintenance or repair works
- Skills and Training
- Management of exceptional transports
- Measurements of user satisfaction
- Measurement of personnel satisfaction
- Research and development programs

The performance of all activities is compared regarding to:

- philosophy,
- method,
- extent,
- recording/storing of data,
- frequencies,
- organization,
- personnel skills,
- cost.

For general comparisons the characteristics of the bridge stocks and road networks were also collected.

The report on the study will be finalised in 2003.

3.1.3 Repair of Bridges under Traffic

The traffic management during repair/maintenance works appeared to be an issue of this topic Asset Management.

It had already been addressed by the Committee C11, published as the Committee report for the Marrakech Congress 1991 (PIARC Reference 19.11.B) and “Repair of Bridges under Traffic” (PIARC Reference 11.03.B).

It appeared that the reports covered the main aspects of the repair of bridges under traffic and that the principal conclusions were still valid. Therefore, it was decided to update the report using the experience of the Committee and to propose it as an article for Routes/Roads (N°317 – January 2003). It deals with:

- traffic restrictions (information policy and economic aspects),
- traffic arrangement and working safety,
- inspections and additional investigations (tools to work under traffic),

- general consideration on maintenance and renewal (such as the importance of the planning, structural safety, temporary bridges)
- maintenance and renewal of bridge components (replacement of bearings and expansion joints, waterproofing, surfacing, structural renewal)

- feedback on bridge design in order to facilitate repair under traffic and minimize maintenance
- research and developments

3.2 Performance Management

3.2.1 Towards a performance management of bridges

Historically, technical considerations were always dominant in structure management and the definition of priorities of works. In addition to these technical criteria, countries have been developing policies which takes much more into account of:

- requirements of the users of infrastructure which can be regarded as a “customer”;
- economical consideration for an optimised use of the public funds, and the justification in terms of best value for increasing social demand of road safety.

Consequently new concepts and tools need to be developed.

C11 has gathered valuable information from 18 central and local road administrations in Asia, Australia, Europe, North America and Africa regarding management systems, with questions about:

- requirements of users, owners of infrastructures and community.
- management systems of the structures
- users cost and benefit, concept of cost over the lifespan (whole life costing)
- impact of the costs related to traffic
- safety of users and structure
- and questions much more focused on economical consideration such as whole life costing (WLC), discount rate, etc.

The aim of whole life costing is to compare the merits of alternative options for projects in a rational manner by taking account of all future costs in addition to the initial (construction) costs. Such comparisons are made while considering new projects, as well as during the life of a project when choosing management strategies.

The future costs considered in whole life costing generally include all maintenance, operating and replacement costs. Although the process is referred to as costing, all future benefits and incomes also need to be taken into account.

It is clear that such an approach is very attractive but its application to bridges is confronted to some difficulties, particularly linked to the very long life span of the bridges:

- Uncertainty of Maintenance Needs
  Bridges are traditionally long-life structures, their engineering life being generally in excess of 100 years. Trying to determine the maintenance needs of bridges being built today for the whole of their life must therefore be considered as a doubtful exercise.

- Uncertainty on traffic and loads evolution

- Discount rate
  Discounting of future costs and benefits to present value, using a high discount rate (e.g. 6% in a great number of countries) has the effect that all calculations, beyond about 30 years or so, become insignificant. As such, WLC is particularly appropriate for short life projects. Long life projects, such as highway structures, pose a number of difficulties regarding WLC.

3.2.2 Bridge Management - Results of surveys in Asian and Australasian countries and in African countries

See the main conclusions in § 2.

3.3 Bridge and Structure Conditions

3.3.1 Indicators for Bridge Performance and Prioritization of Bridge Actions

The initial survey and a customized follow up questionnaire, asking the current status of bridge management systems used and performance measures employed, ware to establish the effectiveness of current bridge management systems in two specific areas:

1. Criteria used to assess bridge performance, with specific reference to :

   - safety
   - serviceability including functionality
   - structural condition (adequacy/deterioration)

2. Indicators considered when setting priorities for repair, rehabilitation and replacement of bridges, including such factors as:
    - damage and defects
    - essentially for public use
    - cost benefit to the network owner and road user
    - effectiveness of maintenance carried out

The report presents feedback on the following:

- the findings of the survey
- the effectiveness of Bridge Management Systems
- guidance is provided for performance measures that could be used for a basic system and for those more advanced.

This information should be beneficial to bridge owners in documenting and tracking the performance of road bridges and other structures. It complements a previous PIARC Report titled “Towards an Indicator of Health Conditions of Bridges” (PIARC Reference 11.05.B). In addition, the findings also complement the work of C11 Committee report entitled “Socio-economic Demands and Modifications of Bridges” (PIARC Reference 11.07.B).

3.3.2 Survey on Rehabilitation Actions of Concrete Bridges

The purpose of the study is:

- to identify and evaluate the effective current practice for various bridge rehabilitation actions which have broad applicability for a majority of bridges.
- to provide the bridge engineer with practically informative examples on the various bridge rehabilitation intelligibly.

This report presents a review of rehabilitation actions for concrete bridges structure and comprehensive directions of future research activities based on 22 examples of actual practices of various rehabilitation through a preliminary and a supplementary questionnaire from 9 road administrations in the year 2001/2002. This review covers the following main points:

1. Principal types of damage and defect, and causes in concrete bridge components
2. Inspection, investigation and diagnosis
3. Methodology for selection of rehabilitation actions
4. Rehabilitation action
    - to cope with salt/chloride attack, freeze/thaw, overloaded, poor drainage and poor execution and other defects
5. Necessary research and development in the field of :
    - inspection to supplement visual inspection and investigation of the durability of concrete material with various non-destructive testing as a part of broad approach
    - rehabilitation and strengthening techniques

4 – INVITED PRESENTATIONS

In order to generate discussion on future topics for the Committee, two invited speakers have been invited to make presentations.

The purpose of these contributions is to illustrate how two African countries (Madagascar and South Africa) have define their bridge management policy, the organization and the tools implemented, the difficulties encountered, the future developments expected and their perspectives.

- **Management of bridges in Madagascar**

by Mrs. Célestine RAZANAMAHEFA - Directeur des Ouvrages d'Art, des Travaux maritimes et fluviaux of the Ministry of Public works of Madagascar

In 1997, the Ministry of Public Works of Madagascar, supported by European Union, has restarted the activities of maintenance and survey of bridges (number of bridges: 3000, length of the network 15 000 km), after the report of the difficulties encountered regarding material resources and organization when applying the Technical Instruction dated 1988. A new policy has been defined for the whole network of the road system considered and the following strategy has been adopted:

1. *the systematic inventory and the introduction of reference inspection*
2. *the implementation of the survey system with two levels : the current survey, the periodic survey (annual visit and detailed inspections)*
3. *the programming of the current and specialized maintenance*
4. *the identification of bridges to be rehabilitated*

Since 1997, it results practically in:

- *the implementation of the bridge network*
- *the execution of studies and works on several main roads*
- *accompanying actions: training of concerned actors in the field of bridge (Administration, firms, local authorities, etc.).*

Nowadays, the inventory is 2/3 completed.

- **A South African perspective on bridge management and some unique problems encountered**

by Mr. Edwin Kruger – Bridge Network Manager – The South African National Roads Agency Limited (corresponding member of C11)

This presentation will deal with the implementation of the new BMS adopted by the SA National Roads Agency. Reasons will be given as to why the present BMS was adopted and how it differs from other systems. Also to be discussed is the overall road network Bridge Performance Indicator(s) to be adopted by the SA National Roads Agency. Examples on how the Overall Priority Index (OPI) and other information was used to identify and group bridge repair projects will be given. The different approaches used for the procurement of contractors to undertake the repairs and the problems encountered with the bridge repair design process will also be dealt with. Finally, some unique bridge problems encountered in South Africa will be presented.

5 – CONCLUSIONS AND TOPICS FOR THE FUTURE

It was found that there existed many different situations and conditions of bridges in countries. A comprehensive strategy for the large size of national bridge stock, and sound maintenance and management of bridges is required on the basis of an overall long-term plan. It is essential for effective road networks under the restrictions of limited availability of finances and resources.

"Bridge Management" encompasses, in the broad sense, all activities related to how a bridge owner builds, operates and maintains his bridges at network level, as project level to have a proper running maintenance and thereby minimize rehabilitation works and disturbance for road users as well.

Bridge Management System is an organizational and decision assisting tool to develop annual and long-term maintenance and improvement programs and budgets. The goal of bridge management system is to be able to deal with:

- overall condition of any bridge in the network level,
- condition of specific component of bridges,
- potential maintenance and rehabilitation plan,
- assisted service life cost of such plans with optimized allocation of funds.

For proper and systematic maintenance and management, inspection and assessment of bridge structure are the basis. From the view point of resources bridge inspectors need to be sufficiently trained and proper manual should be provided. And monitoring and non-destructive test and loading test are effectively used in evaluating the health condition of bridges. It should be emphasized that continuous supply of human and financial resources is required.

As the recommendations for future, the challenge mentioned below can be overcome with improved technology such as non-destructive techniques for investigation and cost-effective rehabilitation techniques, better tools for management of bridges, and the adoption of appropriate policies.

- Challenge to keep the function and the condition of bridges with lower and easier maintenance under increasing load and increasing traffic.
- Challenge for the coordination of the maintenance work for the whole network based on the continuously refined and improved management systems by expanding the database and by adding new analytical tools and noble goals.

There are plenty of areas where the work of Committee C11 may be usefully extended in the future. The aim would be, on the basis of the discussions and exchanges with the floor in Durban that are expected fruitful, to identify some topics on which C11 would be recommended to work in the next period.

In order to launch the discussion, some proposals from Committee 11 are listed below:

Durability

Low and easy maintenance
Design and detailing for durability
Bridge design and maintenance sustainability
Technology to extend lifetime of existing and new structures
Quality of repair work
Feedback to new bridge

Investigation Method

Non-destructive testing
Prestressing condition and force
Monitoring sensors

Finance linking with maintenance

Safety

Risk management under severe conditions
Legal aspects for existing bridges
Probability based management
Modeling of future performance

Equipments (design, construction, maintenance)

Management of historical bridges

Whole life costing analysis

It should be also recommended that the work of Committee 11 will consider as far as possible not only bridges but also other structures such as retaining walls, gantries, etc.