1. INTRODUCTION

The Technical Committee 45 LTO "Long-term observation of concrete structures" was established in 1979 in Paris. This setting up of the Committee was prompted by the recommendation of the RILEM Permanent Committee meeting held in Budapest (Hungary) in 1977. The working programme was accepted at the Permanent Committee meeting in Athens (Greece) in 1978. It was agreed in principle that the Committee would study the experimental methods as well as the results of the long-term observation of various concrete structures, this work being connected with the analysis of the structural reliability of concrete structures, their serviceability as well as the theory of predicting service life and behaviour of similar structures. It was underlined that this Committee should be practical and able to prepare a guide of good practice for long-term observation of structures. The members of LTO 45 Committee were required to prepare general recommendations on unified methods and recommended equipment for long-term observation of structures covering bridges, buildings and special structures. The author of this report has been elected to chair the RILEM 45 TC to activate and co-ordinate the best specialists in Europe and overseas in order to gain the maximum information, which could be used by the members of the Committee to work out the basic recommendations.

The Technical Committee 45 LTO issued 5 tentative recommendations and two state-of-the-art reports and finally organised an international symposium on "Long-term observation of concrete structures" in 1984 in Budapest (Hungary). The tentative recommendations are the following:

- long-term observation of bridge structures (drafted by T. Jávor);
- vibration test in long term observation of concrete bridge structures (drafted by B. Zakić);
- prestressing test of prefabricated elements (drafted by B. Zakić);
- long-term observation of concrete buildings (drafted by J. Chabowski);
- measurement of cracks (drafted by P. Schiessl).

The state of art reports are the following:

- analysis of temperature gradient effects (prepared by M. J. N. Priestley);
- the possibility of evolving a theory for predicting the service life of reinforced concrete structures (prepared by K. F. Müller).

45 LTO met regularly in various countries: 1979, Paris (France); 1980, Opatija (Yugoslavia); 1981, Munich (F. R. Germany); 1982, Garston (Great Britain); 1983, Espoo (Finland); 1984, Budapest (Hungary); 1985, Lisbon (Portugal). The members of the Committee were coming from 20 countries. The T. C. collected much information relating to the national standards of various countries. More information would be required on ageing tests and on the definition of the problem and criteria with respect to testing of materials, preparation of specimens, long-term tests and service conditions and interpretation. The prediction of behaviour can be based on studies of analysis of general rules of behaviour of structures, linking long-term observations of structures in the past and organisation of observation to predict behaviour in the future.

2. SERVICE LIFE OF CONCRETE STRUCTURES

The need for predicting the service life of structures may result from different circumstances. The main cause are deficiencies of the structure raising the question whether repair is profitable. Service life is the period during which a structure or a portion of a structure fulfils all functional requirement to a certain, well-defined degree. With old
structures we are concerned about the remaining service life. If we succeed in calculating the service life of r. c. structures, we gain a valuable aid for economic planning. But we need not wait for this end. Stimulation for a better execution of work can already be expected from a better understanding of deterioration mechanisms offered by the necessary fundamentals of calculation, which demonstrate convincingly how detrimental certain influences are, not to forget bad workmanship and its long-term effects. Thus work in this field promises useful practical results well before the final goal is achieved.

The development in recent years with increasing air pollution, increasing need of energy saving and, last but not least, the growing number of damage in old structures leads to a raising demand to calculate the durability of structures, too. In principle, it is possible to evolve a theory for predicting the service life of r. c. structures and to devise how that could be achieved. Service life studies will be necessary for new and existing buildings of different ages, which means that we have to discern between total and remaining service life. An estimation of the total service life will normally be based on the assumption that the execution of works and the use of the structure are in conformity with codes so that characteristic design values are a well fitting basis of computation.

There are 3 ways of obtaining quantitative values of service life:

- A purely statistical approach by checking the overall service life, a usual method e. g. in housing stock surveys and by bridge maintenance staffs; since construction materials and methods vary with time, different populations must carefully be separated to avoid misinterpretations. The method is very valuable for general financial planning and housing stock maintenance. The way, however, is irrelevant for research towards methods of calculating service life.

- The deterministic way of trying to find out the real processes and the development of deterioration with time into the “limit state of damage”, introducing the medium or the characteristic behaviour into calculation models, the “deterioration models”. A comparable way has been used up to now in bearing capacity calculations for structures. For calculating service life we have to study the changing of bearing capacity with time and develop calculation models, which combine the “deterioration model” and the “mechanical model” to formulate the “deterioration process”.

- The probabilistic way by using models that have been developed by the deterministic approach and taking into account the scatter of important factors. The ways can be followed simultaneously, thus promoting each other.

Suitable examinations are necessary for each deterioration factor to fix the relevant time-deterioration-curve, which gives an idea of the expenditure necessary to gain basic data for service life calculations. However, for the corrosion of reinforcement, which is by far the most important deterioration process of r. c. structures, quite a lot of research results are available for immediate use. For other detrimental influences, too, many data on the rates of deterioration necessary to formulate the relevant process are available or could be extracted by relatively small effort. Here, as many times before, international cooperation could procure valuable aid in collecting the existing data.

The “limit state of damage” must be defined unequivocally.

When we try to calculate the service life we are only interested in time-dependent limit states. Therefore, defining these limit states demands glancing far ahead into future. Uncertainties in the calculated service life, that are related to assumptions about future development, are unavoidable and have to be put up with. If necessary, the results can be corrected from time to time. For defining limit states and the relevant safety coefficient the few following reflections give a rough draft of the open problems.

The limit of serviceability can be reached with early warning, e. g. by cracks, large deflections due to scalling or without forewarning, e. g. due to a sudden large deflection after rupture of a tendon. The partial safety ensuring the necessary distance to the limit of serviceability may be consumed completely since there is no danger whatsoever for passengers or personnel. Repair measures can restore the serviceability for more or less long periods. In certain cases it could be suitable to stop repair measures, which means not to stop the deterioration process and to wait until the structure reaches the “limit state of bearing capacity”, a decision which in most cases will be based on economic considerations.

3. MEASUREMENT AND EVALUATION OF CRACKS

Observation of cracks is important to judge the actual condition and the anticipated long-term behaviour of a structure as well as to give data which are necessary to calculate the service life of structures. The cause and manifestation of cracks in concrete structures is summarised by Prof. P. Schiessl in table I. The type of measurement of cracks is visual (crack pattern), nondestructive (internal cracks) or destructive (crack-widths).

For visual inspection, the measurement of the width of actual crack at the surface of the structure we can use a crack comparator (accuracy 0.1 mm), a comparator with magnifying lens (accuracy 0.05 mm), a microscope (accuracy 0.02 mm), a crack-monitor (accuracy 0.5 mm), a crack movement indicator (accuracy 0.02 mm). For the nondestructive testing of cracks we are recommending ultrasonic testing with the through-transmission technique.

4. EQUIPMENT AND METHODS OF LONG-TERM OBSERVATION

In a long-term work of structural observation the equipment and methods used as well as the methodology of analysis and interpretation are always in close relationship, and depend on the technical and economic interest of the structure concerned, on the capacity of execution of the entity in charge of observation, and on the object of the work. Since the beginning of this structural engineering activity, for most structures observed the manual system has been adopted. For this purpose a technical team periodically visits the structure and uses the mechanical, optical or electronic equipment required for the observations. In the course of the past two decades, owing to the great progress achieved by automation and electronics, long-term observation could be carried out by automatic means and following programmes previously established, thus avoiding the need for teams to visit the structures.