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sucht: diese Verminderung ist nur möglich bei genauer Kenntnis der Phänomene und ihrer Folgen. Wenn man in die Wahrscheinlichkeitstheorien Vertrauen hat, ist deren Verwendung nur möglich auf Grund einer bekannten Verteilung der mitspielenden Variablen.

Sowohl was die im Brückenbau vorkommenden Baustoffe betrifft, als auch was die Tragwerke selbst angeht, ist es unerläßlich, so schnell als möglich auf internationaler Ebene gut programmierte versuchstechnische Forschungen zu verwirklichen. Dies sollen geordnete und koordinierte Versuchsreihen statistischen Charakters sein, die die tatsächlichen Eigenschaften der eingesetzten Baustoffe und das statische und dynamische Verhalten der Brücken, letzteres einschließlich der allgemeinen Verformungen und der Spannungen, erfassen.

General Report

a) Progress and Failures in Bridge Building

It may be stated that fairly satisfactory progress has been achieved since the Lisbon Congress, both in regard to reinforced concrete and prestressed concrete.

It would seem, however, that such advances as have been made consist not so much of the development of entirely novel techniques, as of improvement in our knowledge of the consequences of the use of materials of greater strength and in the choice of higher working stresses. The non-homogeneous character of the papers submitted makes it impossible, however, to give any definite indications of present tendencies.

We shall first of all attempt to make a synthesis of these reports and associate them as far as possible with a general trend.

M. C. Fernandez Casado describes some applications of prefabrication to the construction of four reinforced-concrete arch bridges, one of them being of the bow-string type.

The arches in question were precast, in the workshop or on the site, in several sections for which the chord after erection is equal to or less than the actual span of the arch, and in the latter case the butt-ends of the spans are constructed by corbelling out from the supports. In all cases the arches have 3 hinges which may be temporary or permanent, and raising is carried out by means of a wind-braced steel tower, which permits of a temporary crown support of the arches.

The precast members are given their final dimensions in some instances, while in others they form the centring for the construction of the actual section and in such cases they remain embedded in the structure.

The arches are connected by means of precast transverse beams which may be prestressed, if necessary; in one case, the prestressed deck slab for the roadway was also prefabricated. For two of the structures the stability conditions at every stage in the erection were determined by tests on models. The technique of prefabrication is, on principle, interesting; the advantages it affords are well known, at least where large numbers of identical elements have to be constructed, such as the bridges on a motorway, for example. In the extremely important cases studied by M. C. FERNANDEZ CASADO, in such a masterly manner, it would be desirable to have an estimate of the economy achieved, including the savings resulting from the improvement in the quality of the concrete, with the consequent reduction in weight and in the cost of the superstructure and of the infrastructure.

Professor GIBSCHMANN and M. LITWIN report on the situation now prevailing in the U.S.S.R. with regard to the construction of prestressed concrete bridges for motorways. Two tendencies are apparent: one consists in the designing of standard types of bridge to be built in large numbers, the other envisages special arrangements for important structures where the design may vary from one case to another.

The prestressing cables are anchored at their ends in a steel device comprising a sheath in which the wires, previously bent, are grouted with concrete. The girders are T, I or box beams and their height is usually equal to $^1/_{20}$ of the span. The girders for the majority of the standard types of bridges are precast and are put into position by suitable hoisting-gear. The weights of the girders range from 52 to 80 tons depending on the span. The girders are either monolithic or composed of members cast in steel shuttering and connected together by prestressing. All the structures are subjected to tests before being opened to traffic and are systematically inspected.

For small structures, the transverse section is frequently an open-topped box caisson, while the deck slab forming the carriageway is precast and made integral with the caisson on the site.

The large beam bridges are frequently erected with corbels hinged to one another in the centre of the spans, or serving as supports for isostatic central beams; the corbels are sometimes formed of voussoirs joined successively by prestressing cables in the upper part.

A type much in favour for wide spans is the bridge with an upper deck constructed of semi-arches hinged on the supports and maintained by a tie-beam situated at the emplacement of the deck. The tie-beam acted upon by the weight of the semi-arches is subjected to an additional prestressing after erection of the components of the slab forming the carriageway.

The authors consider that it is an economical method of construction to build continuous beams from isostatic girders connected together at the supports by prestressing applied subsequently to the erection of the beams. Finally, they draw attention to the construction of bridge piers built above the highest level of the water in the river from precast hollow members connected by prestressing and subsequently filled with concrete.

M. R. MACCHI suggests a new method for anchoring prestressing cables formed of wires. The device belongs to the type of anchor comprising a movable head, made of suitable steel, in which the wires are anchored. Several of the systems of anchoring already known involve the formation in the wire, by upsetting, of a sort of rivet-head, thus causing a discontinuity between the rivet-head and the actual wire.

M. MACCHI, on the contrary, has carried out a flattening of the wire along two symmetrical curved surfaces giving rise simultaneously to a gradual reduction in the dimension of the wire in the plane of application of the distorting force and a gradual enlargement of this dimension along a cone, in the perpendicular plane.

The movable head has a number of cone-shaped recesses corresponding to the number of wires in the prestressing cable.

The advantage of this arrangement lies in the constant value of the transverse section of the wire; furthermore, the oil-operated press employed for carrying out the deformation occupies very little space and is easily used on the site. It is possible, as in the case of wires upset to form a rivet head, to have two anchoring heads on the tensioning side separated by a distance approximately equal to the elongation of the wire. The author points out that the cold working, by this process, of steel of the grades generally employed, including that known as piano-wire, does not give rise to any brittleness or tendency of the material to crack; according to the author, the favourable results of static and fatigue tests confirm the safety of this anchoring device.

It is well known that the formation of rivet heads by upsetting the wire along its axis may give rise, in the case of certain categories of steel, to longitudinal cracks due to the occurrence of tensile stresses in a direction perpendicular to that of the compressive force. These cracks, provided they remain longitudinal, do not appear to be dangerous, although no certainty exists that they may not subsequently spread into transverse cracks from which danger is to be particularly apprehended.

In the case of the method of flattening the wire suggested by M. MACCHI, the forces necessary for the cold-working are apparently not so great, but they must theoretically give rise to tensile stresses directed along the axis of the wire.

It would be useful to have some information regarding the definite absence of cracks due to these stresses, because such cracks would be transverse to the force acting on the wire; furthermore, some assurance should be given in regard to the protection of the wire during the grouting of the cables with concrete.

The report by Professor Dr. K. SZÉCHY deals with a general problem, capable of application to all girder bridges, whatever may be the type of material employed in their construction, and is concerned with the design and method of calculating the end abutments in contact with the soil.

The motive which prompted the author in his work may be readily endorsed, namely, that although the superstructure of bridges has been the subject of the most careful attention and of numerous researches, resulting both in economy and in an improvement in appearance, the infrastructure, on the contrary, has scarcely undergone any development in regard to its design or concerning the method used for its calculation. The researches undertaken by M. SZÉCHY are not yet complete, but he has three aims in view:

1. The logical design of abutments with the object of securing a better utilisation of the materials and of eliminating any weakness in the component parts.
2. The establishment of an approximate method of calculation which takes into account the monolithic character of this part of the structures.
3. Approximate determination of the effects of the earth pressure, taking into account the deformability of the actual abutment made monolithic with the wing walls.

For structures of small span, the abutments and the superstructure resting on supports, but for which the joints with the abutments have been eliminated, may be regarded as a portal frame. The beams hinged at the ends take up the compressive stress at the head of the abutments, while the abutments are regarded as having their bases embedded in the foundations.

When the span is greater (16 to 20 metres), the effects of temperature fluctuations become considerable and some other design must be employed.

The flank walls, whether straight or oblique, are anchored in order to prevent any general movement due to the thrust of the earth acting on the abutment; they thus form lateral supports for the abutment which is regarded as a plate, tailed-in at its lower end, resting laterally on the flank walls from which it receives moments due to the action of the earth upon these return walls, and free at its upper edge. Only the horizontal component of the action of the earth is taken into consideration, while the effects of the centred compression and tension (flank walls) are neglected.

The author then applies the approximate method due to Marcus for calculating slabs by equalising the deflections of the horizontal and vertical sections of the abutment. He draws diagrams of the moments over the entire area of the plate. This theory has been compared in a satisfactory manner with the results of a tensiometric study on a sheet-steel model. These results have also made it possible to determine the action of the mass of soil between the abutment and the flank walls, since its effects are obviously different from those of an undefined mass of earth.

The ideas of the author, when applied to the calculation of several structures erected in Hungary, have resulted in substantial economies in the cost of the infrastructure. Apart from its own intrinsic interest, this research is linked up with a principle which, generally speaking, is not sufficiently applied and which consists in making an element of an engineering structure (in this instance the flank walls) as far as possible answer several purposes: fulfil its own particular function and contribute to the general carrying capacity of the structure.

At this point, we would like to draw attention to the principle of construction of a motorway bridge, with a span of 20 metres, built in Belgium, over a river. This bridge is a portal-frame structure: the prestressed concrete deck is integral with the abutment which is extended into the earth by reinforced concrete piles. The calculation of this structure was carried out by taking into consideration the thrust exerted by the earth in contact with the abutment and the contiguous piles which were driven by water-jet. Obviously, certain assumptions had to be made with regard to the thrust coefficient, the value of which was determined in relation to the deformations of the structure.

This undoubtedly somewhat novel design enabled quite substantial savings to be made in the cost of the deck, while the abutments not only serve the normal purpose of retaining the earth, but moreover play an active part in enabling the bridge to fulfil its function.

Since the last Congress, the methods for calculating reinforced concrete have been the subject of important research work and definite progress has been achieved in those methods which it has become customary to term methods of calculation to failure.

If, at least so far as we are aware, these methods have not yet been applied to the calculation of bridges, this is due to the fact that in spite of the numerous tests that have been carried out, they have not been performed in a sufficiently logical manner, and that furthermore certain factors of the utmost importance for bridges, such as time and the effects of repeated loads, have hardly been investigated at all.

An undeniable fact is the use of increasingly high working stresses in the reinforcement steels for which increasingly hard grades are being employed, and this raises two important problems, namely, the cracking of the concrete and the adhesion of the reinforcement to the concrete.

There have been a great many investigations dealing with cracking, notably in regard to the width of the cracks and the distance between them. It would seem that the application of the various theories that have been worked out in connection with these questions lead, in the majority of the cases commonly met with, to equivalent approximations.

In fact, the interest of these researches lies mainly in the fact that they reveal once more the necessity, well known to designers, for taking precautions against cracking and more particularly because the use of high-strength steel with high working stresses promotes the formation of cracks.

The bond between the reinforcement and the concrete governs, to a large extent, the mode of cracking and is also an important factor in the transmission of stresses from the reinforcement to the concrete.

The mechanism and the magnitude of this bond have also been extensively investigated, but the results obtained so far are contradictory and it would even seem, according to Professor Rüsch, that the discrepancies are due to a different understanding of the phenomenon.

The use of high-tensile steel, rolled in the form of indented bars, necessitates an increased bond and also enables this increase to take place to an extent that varies with the form of the indentation.

We hope to be able to confirm the decisive influence of surface roughness, or more generally the surface condition of the bars, on the resistance to slip. Tests performed recently at the University of Liège, and not yet published, on the adhesion of prestressing wires, show a fundamental difference between the behaviour of a smooth wire and that of a rusted wire. Whether we are dealing with a pull-out test or with tests on deflected beams in which the reinforcement is obviously located in the strained region of the concrete, the break in adhesion for a wire in the as-rolled condition (adhesion being understood in the widest sense of the term: actual adhesion prior to any slip + frictional adhesion + adhesion due to any possible mechanical keying in the concrete) is complete as soon as the first slip occurs, or rather as soon as this takes place the stress (tensile stress on the wire in the pull-out test or bending stress in the beam) rapidly decreases. When the wire is rusted, on the other hand, the load continues to increase and when a generalised movement of slip takes place, it reaches two or three times the load observed when the initial slip occurs.

Furthermore, the behaviour of the rusty wire is equivalent to that of an indented wire (in the as-rolled condition, and hence not rusted) commonly employed for structures in which maintenance of the pre-stressing is ensured by the adhesion of the reinforcement.

We have attempted to define the surface condition of the rusted wire by means of a number and we have obtained a fairly good correlation between this number and the breaking load for total adhesion, but we have not yet made a sufficient number of experiments.

It is not impossible that systematic researches along these lines would enable the surface condition of the wire to be evaluated from the point of view of adhesion, provided that it is possible to define this surface condition in an objective manner and on the site of work.

The problem of crack formation, governed by adhesion and resulting from the utilisation of a high-tensile steel, is therefore of intrinsic importance and also because it throws light on the precautions to be taken in structures as far as their preservation is concerned. But we consider — and we thus confirm the opinion expressed on numerous occasions by Professor G. Wästlund — that in many cases the deformation of structures entails a greater number of disadvantages than does the cracking due to deflection or to the shearing force. Owing to the effect of the loads and the resulting flow, the deformation may increase to a far greater extent than the width of the cracks.

The deformation of structures must be studied in conjunction with the formation of cracks and adhesion because it is equally inseparable from the effects of the utilisation of high-tensile steels.

Again in connection with the use of these steels, it is advisable to draw attention to the favourable results obtained by Professor GRANHOLM from the employment of skew stirrups made of mild steel as shear reinforcements. Quite apart from the fact that it is difficult, and often impossible, to bend half-hard steel bars, the placing of the concrete is made appreciably easier by the elimination of bars bent at 45°. This conclusion, if it should receive confirmation, would be deserving of consideration for general application.

A great many applications of prestressed concrete have now been made in hyperstatic structures.

These structures raise many problems including that of the friction resulting from variation in the curvature of the cables inherent in the variation of the bending moments.

These cases of friction must be taken into consideration at the design stage in order to eliminate or reduce the causes which may give rise to them during the construction and which result from the calculation and the lay-out of the cables. In this connection, it is well known that if the losses due to friction are underestimated a considerable reduction in the safety factor may ensue, and if they are overestimated, and consequently an increase in the prestressing force takes place, a considerable increase in the tensile stresses may result.

Cables with double curvature must be avoided and special cables must be provided to take up the tensile stresses at the supports.

In many continuous bridges, it is frequently considered to be advisable to eliminate, at least partially, the effects of shrinkage, the deformations arising from prestressing applied to the entire structure and the additional hyperstatic reactions resulting from the prestressing of the bridge as a whole. The beams are then made isostatic during their construction by the formation of temporary joints and hinges which are subsequently blocked by filling with concrete and prestressed in order to re-establish continuity; these temporary cuts are indispensable when the beams are precast.

The joints must be made as far as possible in the vicinity of the section of zero moment under uniform loads and not near the support.

These sections of the beam are assembled by means of so-called continuity cables (Guyon); connection by means of half-hard steel reinforcement bars with increased adhesion is also possible, but in that case concreting must be carried out over a length and depth sufficient to enable the joint between the two sections of the beam to be made by adhesion of these reinforcements. The methods of calculation for prestressed concrete show a considerable development in depth, notably as far as compressive and flexural stresses are concerned; it would, however, be useful to have fuller information regarding resistance to a biaxial stress, since such a stress is always present in bridge decks, either as the result of longitudinal and transverse prestressings, when they exist simultaneously, or owing to the effects of the longitudinal prestressing and the loads.

Calculations to failure have been the subject of important research work, taking into account both the conditions of static equilibrium and the deformations, but the resistance to shearing forces has been less thoroughly investigated owing to its complexity.

As in the case of reinforced concrete, the use of concrete and of wire of high mechanical strength leads to substantial reduction in the dimensions of the structures, and this necessarily gives rise to important problems which have so far not been tackled to any great extent; we have in mind, more particularly, instability phenomena such as the warping of the flanges of large precast girders during handling, and the behaviour and stiffening of the relatively thin webs of box girders.

As far as the raising of the tension in the wires is concerned, it is not without interest to draw attention at this point to the opinion of the French school recently expressed in Belgium by Monsieur F. DUMAS, Chief Engineer of Highways and Bridges[1]).

"Finally, the fact of employing to the full all the potentialities of the steels, by stretching them to the maximum extent which their yield strength and the tensioning conditions will permit, after having cold-drawn them at least to an equal extent, provides a definite factor of safety for the structures. A reduction in the degree of prestressing is, on the contrary, detrimental to the safety of the construction."

It would be desirable that various questions should be raised at the Congress, particularly the problems arising in the prefabrication of prestressed concrete bridges from the utilisation of prestressing bars of large diameter, and from the pretensioning of prestressed structures in several stages.

In conclusion, I would like to draw attention to the building of two structures of a new type constructed by the Belgian Highways and Bridges Department to designs prepared by our colleague, D. VANDEPITTE, Professor at the University of Ghent.

The structures in question are self-anchored concrete suspension bridges with three spans, the prestressing being provided by the carrier cable.

In a continuous beam, where the permanent load is high compared with the moving load, it is reasonable to give the prestressing cables considerable eccentricities, even to such an extent that they lie beyond the space bounded by the extreme fibres of the beam.

By placing the prestressing cable above the beam, except at the ends, and

1) F. DUMAS: Strength and Safety of Prestressed Concrete. Annales des Travaux Publics de Belgique, 1959-5.

by giving it a parabolic curve in each bay, which is generally speaking a logical shape, a suspended concrete beam is obtained, prestressed by the carrier cable, which closely resembles the beam in a conventional suspension bridge.

This system offers two advantages:

1. It provides a beam that is prestressed by cables having considerable eccentricities and these are necessary when the spans are large.
2. Contrary to what takes place in a conventional beam, the moving load gives rise to an increase in the tensile stress in the carrier cable which is not negligible; moreover, this increase acts with considerable leverage in relation to the concrete prism and thus produces a bending moment which has to be deduced from the bending moment induced directly in the beam by the moving load.

These advantages become greater when the spans increase, with the consequence that this type of bridge is manily suitable in the case of long spans and that it may cease to be economical for short spans.

Self-anchoring, which in a steel suspension bridge leads to a reinforcement of the rigid beam subjected to a considerable compressive force, is favourable in the case of a rigid beam made of concrete, where this force provides the prestressing. In the latter case, the ratio between the deflection of the cable and the span increases with the span, whereas it shows little variation in the case of a steel bridge.

This idea has been applied in two bridges built near Ghent; the first of these structures has spans of 18–56–18 metres; the second (see photo p. 579) has spans of 40–100–40 metres and a width of 18 metres. If the first bridge is at the limit as far as economy is concerned, although the saving is still quite substantial, in the case of the second bridge, on the other hand, a considerable reduction in costs has been achieved.

Prestressing was obtained by the raising above the piers, by means of hydraulic jacks, of the portal frames supporting the cables which are placed in position without initial tension and are independent of the deck. There is no prestressing cable in the thickness of the deck.

The concrete for both decks was poured on a scaffolding. This was an economical arrangement, because the canals they span had not yet been dug when the bridges were being constructed, but there was nothing to prevent concreting from being carried out gradually in cantilever, supported on temporary stagings.

Lenths of 300 to 500 metres can be spanned economically by structures of this type which exhibit greater rigidity than a steel suspension bridge.

In concluding these remarks on reinforced and prestressed concrete bridges, it should be said it is a matter for regret that the accidents that have occurred during the building of certain structures have not been disclosed. Whether it is a question of weakness in the design, calculation or execution of the work, or of accidents that may have happened, for example, during the application of the prestressing, owing to the action of frost, through corrosion of the reinforcement, etc., such incidents are always most instructive; their study is capable of leading to useful researches and even, sometimes, to actual progress. In any event, a knowledge of such incidents would be useful to the entire body of bridge builders.

b) Safety

The analysis of the safety of structures must now be considered to the same extent as the actual study of the structures of which it must form an integral part. The subject is very wide; sooner or later it is bound to become a matter for a definite specialisation having its share in the engineer's sphere of activity.

The idea of safety is sometimes comprised within the sense of a wider endeavour to secure economy in structures; this is a restrictive and even misleading concept, because constructions regarded as not being economical at the time they were built have proved to be efficient under working stresses several times greater than those taken into consideration when the calculations were made.

It is not necessary to revise all our ideas, because experience of the examination of engineering structures sometimes shows that the actual stressing of certain elements, such as the upper compression flanges of main-girder bridges without wind-bracing, is not very remote from that determined by methods of calculation which have remained standard practice to the present day.

Furthermore, a great many engineering structures built several decades ago, and regarded as heavy and over-dimensioned, only allow the passage — which may, of course, be infrequent but regular — of exceptional convoys provided great precautions are taken or even temporary strengthening is carried out.

It must also not be overlooked that high-performance materials, when utilised near their limit, may exhibit greater degrees of scatter than materials of standard quality; we have in mind, more particularly, semi-hard or hard steels which are becoming increasingly widely employed both in steel structures and in concrete construction.

The aim of these preliminary remarks is not, however, to deny the necessity for a fundamental revision of the present concept of a factor of safety and of permissible stresses, in favour of the hypotheses based on the theory of probability which assume a risk of total failure provided that the scatter of the criterion of safety adopted and of the stress regarded as dangerous are considered simultaneously.

The safety of a structure depends upon such a large number of aleatory variables, which come into play at every stage between calculation and putting into service, that the factor of safety must, as M. FREUDENTHAL foresees, itself be regarded as another aleatory variable.

The values of the safety factor are distributed in accordance with a law which itself depends on the distribution of other variables, namely, the intensity of the imposed loads S and the criterion of strength R that is taken into consideration.

If we assume that the law of distribution of the imposed loads S, which is the outcome of observation, and the law of distribution of R, obtained from the results of mechanical tests, are both known, it is possible to determine the law of distribution of the factor of safety and hence, for a value of this factor equal to unity, the probability of failure.

M. FREUDENTHAL introduces the concept of "period of recurrence" of an exceptional convoy of loads, expressed as a number of observations made on the basis of the measurement of stresses.

The application of a load of force $\geqq S$ will only give rise to failure provided the condition $S > R$ is fulfilled or if the factor of safety is less than 1.

The conceptions of M. FREUDENTHAL appear to me to be in line with those expressed on many occasions, and with so much authority, by MM. R. LEVI and M. PROT.

The idea of the risk of the failure of a structure, characterised by the probability of a conjunction of circumstances, which would cause that failure, taking place, is far less arbitrary than that of a factor of safety.

This idea was taken into consideration in Belgium recently in order to establish new values for the permissible stresses in steel structures on the basis of the results of an important statistical study of the lower elastic limit of steels.

The failure of the structure will take place when, in any section, the actual stress R reaches or exceeds the elastic limit Re, that is to say, when the condition $Re - R \leqq 0$ is fulfilled, Re and R being two independent aleatory variables.

If σ is the standard deviation and if Re and R are distributed according to the normal law, $\overline{Re}$ and $\overline{R}$ being mean values, we obtain $\overline{Re} - \overline{R} = t\sqrt{\sigma_{Re}^2 + \sigma_R^2}$.

It is assumed, with M. R. LEVI, that $\sigma_R = 0.125\, R$. $\overline{Re}$ and σ_{Re} are determined by the statistical study of the elastic limit.

It is evident that, for a given steel, the probability of failure, characterised by t, increases when $\overline{R}$, that is to say the permissible stress, increases. But this increase bears no relation to the *proportional* reduction which affects the conventional factor of safety $s = \frac{\overline{Re}}{\overline{R}}$.

It is again obvious that no purpose is served by employing steels for which $\overline{Re}$ is high if the scatter of the elastic limit σ_{Re} increases.

Studies of this kind are possible, as M. R. LEVI has shown for reinforced concrete and prestressed concrete construction, but they presuppose the performance of statistical tests which must be undertaken in accordance with very carefully prepared programmes; these tests are, in fact, indispensable in order to complete and define more accurately the methods based on the theory of probability and enable them to be taken into consideration in a practical and generalised manner.

This is in line with the indications given by MM. K. WAITZMANN and Z. ŠPETLA in their paper. They carried out, on 22 structures, certain non-destructive tests which enabled them to determine the quality of the concrete according to a method developed by them in Czechoslovakia. In the first place, on the basis of the results of their statistical study, they give details of the estimation of the most unfavourable combination of stresses in a section of a structure and, secondly, on the basis of theories of the rupture of the concrete, they succeed in estimating the minimum strength of this section.

From their calculations made for compression and simple bending, the authors deduce the value of the true factor of safety.

The work of MM. WAITZMANN and ŠPETLA is particularly interesting on account of the fact that it is based on the actual characteristics of a large number of structures.

The paper by M. H. C. ERNTROY is entirely devoted to a statistical study of the strength of the concrete obtained from cubes prepared on 300 sites.

The initial aim of this study was to establish a relationship between the minimum strength of the concrete determined on cubes and the average strength. On account of the varied nature of the sites of work, nine types of control were employed, depending upon the manner in which the quantities of cement and aggregate are determined.

Assuming a normal distribution of the results, the minimum value was fixed conventionally as being equal to the mean value minus 1.75 the standard deviation.

The author then established a relationship between the average value and the standard deviation; it appears that whatever may be the type of control, the relation is first of all linear and that it is then constant; the age of the concrete seems to have no appreciable effect in this connection.

After having pointed out an almost linear relationship between the ratio $\frac{e}{c}$ and the mean value of the strength, M. ERNTROY considers the effects of several variables (rate of hardening, errors due to the tests, etc.). He shows that the ratios $\frac{e}{c}$ necessary in order to obtain the observed mean value and the estimated minimum value are proportional to one another, and that the coefficient of proportion depends upon the type of control of the quantities of materials employed in gauging the concrete and, above all, on the quality of the control.

This experimental research is associated rather with the quality of the concrete and its actual determination from a suitable composition than with the safety of structures. Its connection with safety is evident, however, if it is borne in mind that safety can only be considered in its wider sense by means of a thorough statistical knowledge of the actual characteristics of the materials employed.

The paper by Dr. A. Rösli deals with the dynamic effects determined on 20 prestressed concrete bridges; it is in close relationship with the theme to be considered. The value of the stress — an aleatory variable — employed in the determination of the probability of total failure, must be that which actually arises and which is subject to a factor of increase due to the dynamic effects. The calculation takes this fact into account by giving this factor a value that is often conventional owing to the lack of adequate experimental investigation.

The question, which has never ceased to be a matter of concern to constructors, seems to be returning as a current topic of interest, because the O.R.E. (Experimental Research Bureau of the International Railway Union) is now undertaking, with the cooperation of several countries, a thorough examination of dynamic effects on various types of steel railway bridge.

The writer of the report has done work of considerable importance by determining, for the structures that were tested, the natural frequency of vibration, the damping coefficient given by the logarithmic decrement and the impact coefficients, together with the increasing variation of the impact coefficients and of the damping in relation to the natural frequency. The increases observed, due to dynamic effects, are sometimes considerable, particularly in the case of the traffic on bridges covered with snow. The results obtained attract attention at a time when endeavours are being made to reduce the weight of structures by every possible means; this reduction in weight is only possible if we have accurate knowledge of the phenomena and their consequences. If we have confidence in the probabilistic theories, their application is only possible on the basis of a known distribution of the variables involved.

Both in regard to the materials employed in the construction of bridges, and as far as the structures themselves are concerned, it is essential to carry out as rapidly as possible, and at international level, carefully programmed, arranged and coordinated experimental researches of a statistical nature, dealing with the *actual* characteristics of the materials utilised and with the static and dynamic behaviour of the bridges, including the measurement of the deformations of the structure as a whole and of the stresses.