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ONE AND A QUARTER OF A CENTURY DEVOTED TO STEEL BRIDGE CONSTRUCTION

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Introduction

The history of bridge construction is closely connected to the history of technical higher education.

The first organization of engineer training in Hungary was the Engineering Institute - *Institutum Geometrico - Hydrotechnicum*, established in 1782, which was functioning till 1850 in the framework of the University in Buda. The development of transport, and particularly the regulation of rivers, necessitated the establishment of an engineering institute.

In 1846, the 'József Industrial School' (József Ipartanoda) was established. The Industrial School and the Engineering Institute merged in the academic years of 1851/52, and the new establishment continued to provide engineering training as a technical institute. In 1856 the Industrial School was transformed into a polytechnic institute of higher education. In the curriculum of this institute the following subjects were entered: hydrologic engineering and road construction, and in brackets: rail roads and bridges. In the period between 1867–70 many outstanding professor-scientists were appointed, among others Antal Kherndl.

In 1871 the 'József Polytechnic High School' was ranked as a university. The University of Budapest soon acquired a good reputation. The regular courses of bridge construction are associated with the activity of Antal Kherndl; consequently the review of the studies, too, goes back to that time.

The object of this paper is to survey the activity of the heads of the department dealing with engineering of steel bridge construction, using the works of Gy. MICHAILICH (1960), I. KORÁNYI (1979), M. IVÁNYI and M. ŜKALOUD (1988).

The First Half-Century

Curriculum Vitae of Antal Kherndl

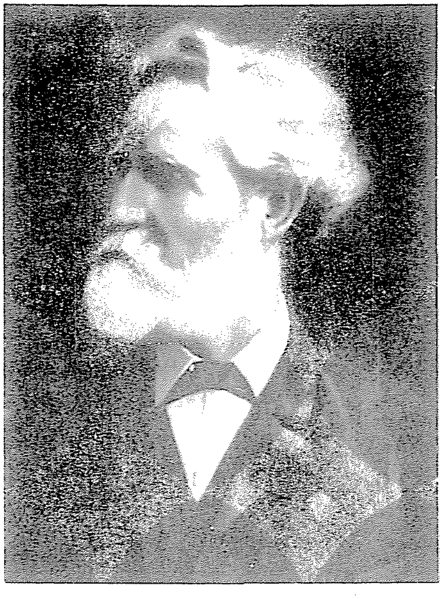

Fig. 1. Antal KHERNDL (1842–1919)

Antal Kherndl (*Fig. 1*) was born on 10th of May, 1842 at the village of Zseliz in Bars County. After finishing the secondary school of sciences in Buda he attended the Technical University of Buda for one year, the Mechanical Department at the Technical University of Karlsruhe for two years and then the Engineering Department at the Technical University of Zürich for two additional years. He graduated from here and received his diploma as M. Sc. in 1864.

As an engineer he entered into service of the State Railways in Baden, took part in the preparatory work of a railway-line construction between Heidelberg and Heilbronn and designed steel bridges. Then he entered into public service at the engineering office of Zürich.

At the age of 25, he was invited to the Technical University of Budapest in 1867. Accepting the invitation he was engaged as an assistant professor for two years and from 1869 he worked as a professor at the University. He lectured on subjects of road and railway construction engineering till 1871 and also hydrologic engineering till 1878 in addition to his main subjects: graphostatics and bridge construction engineering.

The Hungarian Academy of Sciences elected him to be a corresponding member in 1884, then an ordinary member in 1898. The Pázmány Péter University of Budapest conferred to him the degree of honorary doctor on philosophy. The importance of all these honours was further increased by the fact that those are considered as the testimony of the official acknowledgement of the new technical sciences those times. After a scholastic career of 47 years he retired in 1914. The Technical University of Budapest conferred to him the degree of honorary doctor on the occasion of his retirement and by doing so, the staff of the Technical University expressed the deepest acknowledgement and gratitude to him.

His calm rest and peace of mind was distributed by the World War and he died on 7th of October 1919.

The backbone of his career is the scientific, creative activity displayed in the field of graphostatics and bridge construction theory. This trend of his activity was inspired especially by two of his professors exerting a decisive influence on his development. One of them was professor Redtenbacher whose activity opened a new era in the field of engineering mechanics at the Technical University of Karlsruhe, while the other was professor Culmann at the Technical University of Zürich who reached sensational achievements in engineering mechanics by laying the foundations of graphostatics.

The attention of the young engineer was drawn especially by the beauty of the new branch of engineering sciences founded by Culmann as well as the extraordinary practical significance of it, which interest of his was shown obviously by the fact that after finishing his studies he pursued additional studies in graphostatics under the Culmann tutorial for half a year.

Having returned home from Zürich as a professor at the Technical University of Budapest he considered his principal task to promote the development of the Hungarian technical culture in this direction of sciences. With this in mind first of all he adopted the subject of graphostatics and took an immense part in the development of this new branch of engineering with great importance from the point of view of engineering practice with his original works. His activity of this trend was immortalized by his lectures given at the Technical University, by a whole series of his original treatises and mainly by his great work: 'Graphostatics of Beams'.

As a scholar brain he always tries to penetrate to the very marrow of phenomena. His main goal was to give a solution to the problems as simple as possible and the more obviously for the intellect. He lays especially great emphasis on the effort to make the effect of forces understood directly, to visualize the force play of structures, to help thinking on the basis of mechanics instead of determining the formulae in a simple mathematical way, and doing so, to develop a correct feeling for statics. Similarly, he investigated the complex deformation of beams not by using rigid formulae but on geometric way, he tries to make them directly perceptible through static interpretations. On the basis of this he created graphical procedures easy to handle.

Procedure of Kherndl for the Graphical Determination of the Deflection of Beams

From among his numerous procedures, one of the most significant ones was the graphical determination of the deflection of beams. According to this, the moment of fictitous forces related to the action line of force gave the measure of rotation, while the centrifugal moment related to the action line of force and deflection gave the measure of displacement. All these values could be determined by means of plotting a simple funicular-polygon (*Fig. 2*).

This method of determining the deformation was elaborated by Kherndl in 1879, and it was published in the Review of Engineers' and Architects' Society in volume of 1883–1884.

It should be noted that in the second edition of this book, Culmann used ellipse for the determination of displacements, which made the construction more complicated.

Determination of Reactions of an Arch-Beam Clamped at both Ends by the So-called 'Method of σ-Point'

Another ingenious solution of Kherndl was the determination of the reaction caused by load P on an arch-beam fixed at both ends. The beam is generally a statically undetermined structure to the third degree, consequently the three unknowns should be determined from three equations.

According to Kherndl's solution, three equations can be set up, each of them contains one unknown, and in this way, the problem statically undetermined to the third degree, can be reduced to three, statically undetermined to the first degree problems (*Fig. 3*).

This simple solution was rendered possible so that first he determined the gravity centre σ of the imaginal forces $\frac{\Delta s}{\tau}$ which was supposed to be connected geometrically to the free end of the one-end fixed primary system. He assumes the reaction component V parallel to loading force P through this point. The direction of component H is determined in a way

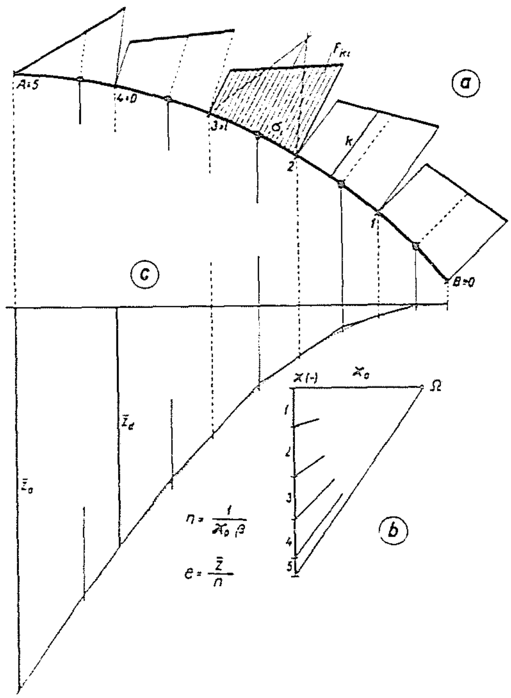

Fig. 2. Simple funicular-polygon

that it should not cause a displacement into the direction of V. The third component is the moment M acting on the free end of the statically determined reference structure.

Accordingly, three equations for deformation can be written. No displacement is caused by force V in direction H, and by force H in direction V acting on point σ, also by moment M, consequently, so it can be written that the displacement of point σ caused by forces V and P will be equal to zero, similarly the displacement caused by forces H and P equals zero. The rotation of the end of the statically determined reference structure will also be equal to zero due to force P and moment M. In this way, three equations for deformation can be written each of them having only one unknown: V, H and M. The obtained diagrams of displacement are the influence lines of V, H, and M.

Kherndl explained his classical solution in a session at the Technical University, and described it in detail in a lecture held in the *Railway Section of the Society of Engineers and Architects* on 13 January 1883. The solution

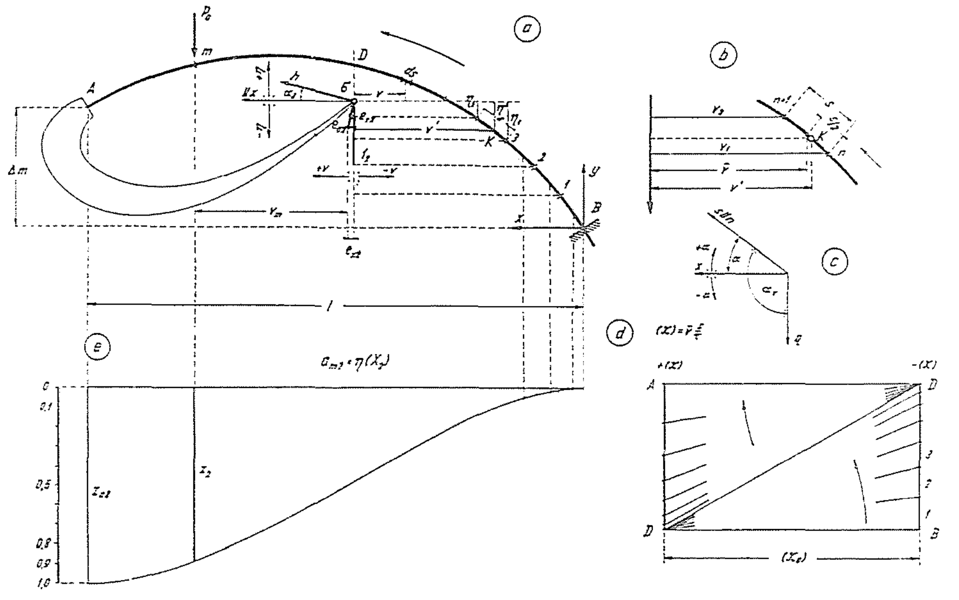

Fig. 3. 'Method of σ-point'

in principle was published in the *Weekly Bulletin of the Society of Engineers and Architects*, too (p. 14, 1883).

Unfortunately this valuable solution was not published in any foreign periodicals. This very simple solution was found out abroad only later on, and it is applied even today.

In the German literature, this method of reaction-distribution can be found for the first time in the dissertation of Müller–Breslau in 1884: Vereinfachung der Theorie der Archit. u. Ing. - Ver. zu Hannover 1884. 575.

Numerous of Kherndl's original scientific papers discuss the solution given to the problems of the most different arches and the stiffening girders of suspension bridges. He explores the play of forces, and breaks up the deformation of the most complex structures, too, into the constituent parts. He considers the supporting structures as a working machine; he is not only interested in its power output but also in the function of each component individually. This analyzing method has the advantage that the measure of the influence exerted by the individual components can be detected directly, which certain reasonable simplification.

He was addicted especially to the problems of the stiffening girders of suspension bridges, which came into the foreground in the course of construction of the Erzsébet bridge, and the reconstruction of the Chain Bridge.

Kherndl's Pioneering Works

In the following, the pioneering works of Kherndl will be represented in chronological order in which he dealt with the different statically undetermined structures first of all, with the suspension structures.

1. *On the Theory of Structures with Statically Undetermined Reaction* (M. K. = Magyar Mérnök- és Épitész-Egylet Közlönye: Review of the Hungarian Society of Engineers and Architects: 1883/84.)

   In this paper, Kherndl first discusses the principles of the determination, and explains his own procedure. He deals with the analytical solution of the different continuous girders, arches and suspension beams.

2. *Graphic Theory of Stiffening Girders of Chain Bridges* (Math. és Term. Tud. Értesitő IX. vol.,1890. Academic inaugural address).

   The principle of the solution to the problem is that there is a point at which the algebraic sum of all motions is equal to zero. Thus e. g., the suspender (hangers), as well as to the displacement of the anchorage chain of opposite sign. The author points out that it is better to use a suspension girder with stiffening girders than a suspension girder alone. He calls attention to the benefits of the suspension girder, the possible load distribution and the reduction in deflections.

3. *On Graphic Theory of Continuous Beams and the Stiffening Girders of Multi-Span Suspension Bridges* (M. K. 1895)

   This paper is directly connected to the calculation of the stiffening girder of Erzsébet bridge because it deals with a three-span, continuous stiffening girder which is suspended only in the middle span. It takes into consideration the deformation of the chain, the hangers and the anchorage at the calculation of tied beam (*Fig. 4*).

4. *On Graphic Theory of Continuous Arches and Rigid SuspensionGirders* (M. K. 1897)

   In this paper, Kherndl deals with the arches fixed or supported on hinges, and the rigid suspension girders.

5. *On Graphic Theory of Hinged Girders of Statically Undetermined Reaction* (M. K. 1904)

   He discusses the play of forces in this paper. These are such multi-span (continuous) beams in which hinges are inserted, but their number does not exceed the limit which would be necessary to statically determinate beam.

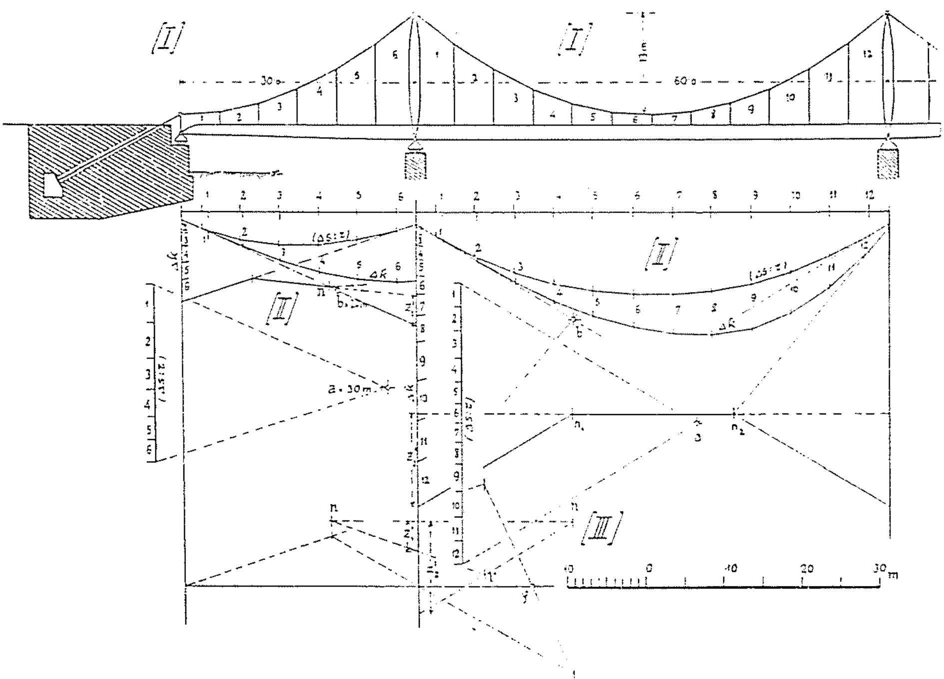

Fig. 4. Graphic theory of multi-span suspension bridges

6. *Graphic Theory of Multi-Span Suspension Bridges with Stiffening Girders.* (M. K. 1908).

First he dealt with a suspension girder having simply supported stiffening girders, and he determined its influence line. The author takes into consideration the elongation of the chain, hangers, anchorage chain, and the deformation of the stiffening girder, as well as the stresses due to the change of temperature and the inaccuracy of anchorage. Finally, this procedure is generalized for the suspension girders having a multi-span stiffening girder.

For the Sake of Completeness the Additional Papers of Kherndl are Listed below in Chronological Order

- *Some remarks of the church in district Lipótváros of Pest, which collapsed during building* (M. K. 1868)
- *Notes on the paper 'Some words about the wall-ties'* (M. K. 1868)
- *Some words on the railway system of Larmanjat type* (M. K. 1869)
- *On allowable stresses for bridge materials* (M. K. 1879). We call fatigue and fatigue limit the phenomenon discussed in this paper.
- *Calculations of long compression member on the basis of repeated loading* (M. K. 1880). According to Kherndl's opinion, the calculation of compression member should be reduced to a tension bar, and after that the rigidity of the bar has to be checked.
- *Some words on the Danube in Pest* (Építő Ipar and Pester Lloyd, 1880)
- *Über die Bestimmung der Dimensionen und zulässigen Inanspruchnahme mit Rücksicht auf die Wirkung der wiederholten Beanspruchung.* (Leipzig, 1881). In this paper, he introduces the factor of safety, and make known the permissible stresses for cast iron, forged iron and wood.
- *Graphic theory of tied-arch-girder* (M. K. 1891). On the competition inviting tenders for the plan of bridges over the Danube flowing through our capital (M. K. 1894).

Kherndl's work: 'Graphostatics of Beams'.

As an especially outstanding part of Kherndl's scientific career this book was which studies the graphostatics elements in systematized form. From his great work '*Graphostatics of Beams*' the first volume was published in two parts in 1893 and 1903. This work was ranked deservedly among the books of similar character published by foreign authors. This great work of Kherndl contains a lot of valuable, new material, and the well-known results were represented in new interpretation and with simple argumentation.

He gives, if possible a general solution to the individual problems, and induces his students to the skill for independent thinking, which would enable them to apply the general solution to the individual cases in practice. His work contains the general theory of plane and spatial frames, the construction of Cremona diagrams, as well as the complete theory of the simply supported and continuous beams. His aim is that the force-play would be followed directly. The main characteristic feature of this work is that it has an absolute scientific spirit, but always with an eye to practical application.

We have to mention the geometric method for the determination of bar forces (or in other words: that of the reciprocal force diagrams, or Cremona diagrams), which is one of the outstanding parts of the work with its thorough explanation. Kherndl explains the rules which makes possible the drawing of the reciprocal force diagrams (Maxwell–Cremona diagrams) — if it is possible at all — starting from the principles which are known from the examinations performed by Maxwell and Cremona with respect to the reciprocity of spatial geometric configurations in the zero co-ordinate system.

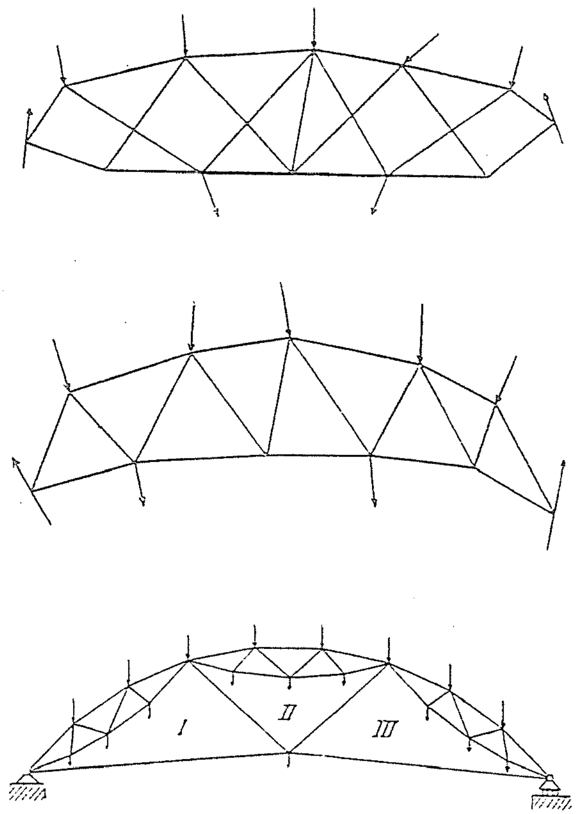

Fig. 5. Loads on joint connections of internal peripherie

Even Ritter and Müller–Breslau apply those rules in their Graphostatics without any derivation — quoting Cremona as an authority — ; though

Föppl made an attempt at the analysing treatment in his work 'Graphische Statik', but his trial was a failure (for details, see the work itself and the criticism published in Periodical 'Archiv d. Math. und Physik', Vol. 1903, p. 158). Kherndl offers, first of all, a more general formulation to the criterion: when it is possible to construct a reciprocal force diagram to the network; this was necessary because Cremona and Saviotti' examinations give a solution to the problem only for that network in which the external forces arise solely on its external periphery, as e. g. it is shown in *Fig. 5./a* (*Fig. 5*). However, this does not contain solution to the case (*Fig. 5./b.*) when — apart from the joint connections of the external periphery — there are loads on one or more joint connections of periphery (I., II., III.), too. Kherndl, with respect to these cases, completes the criterion mentioned above in a sense that the polygon of the forces worked on the joint connections of each internal empty periphery should close individually, afterwards for the case if these polygons do not close (which is the ordinary case): he completes the groups with the assumption of new external forces in a way that this closing should take place with respect to each empty internal periphery, too. The system of forces completed in this way with its action lines — since it can be considered as the projection of the network polyhedron — the plotting of the reciprocal force diagram does not meet with difficulties. Finally, he determines separately the internal forces arising in the bars of the network from the forces assumed for completion, and he subtracts those from the values found in the reciprocal force-diagram with their signs. However, this substraction can be easily omitted (at plane girders) in that case when the complementary forces can be assumed in a way that no bar forces are induced by those. This procedure is fully developed in numerous examples. The new principles are the valuable improvements of the geometrical method of the force determination, which — in this way — covers a much wider scope of application.

Kherndl as a Professor

His teaching activity is similarly imbued with profound scientific spirit. In his opinion, a genuine engineer is characterized by conscious, self opinionated activity, the solid basis of it will be the proper scientific foundation alone. His endeavour was, first of all, to teach the would-be engineers the art of thinking so that they can get their bearings in their wearisome profession, on the one hand, and on the other, he can develop new ideas and, promote the progress. He was teaching at our Technical University for half a century but three years.

The Role of Kherndl and his Followers in the Great Bridgs in our Country.

The technical culture springing up in the wake of Kherndl's beneficial activity resulted in a world-famous remainder, i. e. the Erzsébet bridge in Budapest, which as compared to the old Chain Bridge reveals obviously the immense progress in the field of bridge construction due to the scientific foundation laid down at the turn of the century. While the old original Chain Bridge was ranked among the wonders of the World because its establishment was a really wonderful product of the human brain, intuition and empirical practice, the Erzsébet-bridge was a great credit for the technical sciences. This superb construction is a product of Hungarian character, in which the followers of Kherndl had an overwhelming share. However, the master himself, too, took a great share of it by his papers on the stiffening girders of suspension bridges, on the one hand, and as a judge of the plan on the other.

His leading role in the bridge construction acknowledged Europe-wide should be especially underlined. Among others, he judged the floor-structure plans of the Margit bridge in Budapest, as well as the highway bridge in Szeged, he qualified the plans submitted by the most excellent English, French, German and Austrian engineers and bridge plants. Then he was invited to conduct the strength analysis of the old Chain Bridge, and on this occasion, he began to study the theory of the stiffening girders of suspension bridges thoroughly. And he was the first who built up the graphic theory of those. Afterwards, he had the opportunity for giving a strong evidence of his great knowledge and sharp judgement as a member of an invited international jury for the construction of the Ferenc József and the Erzsébet bridges in Budapest, and in this way, he could demonstrate directly the high level of the Hungarian technical culture for the renowned representatives of foreign countries.

When analysing the plans, he dealt not only with the evaluation of those but he evaluated and discussed the most important contemporary problems of bridge construction, too. He deals with the doubts and worries about suspension and cable bridges with an exceptional command of technical knowledge. In this respect, he examined the possibility of a greater deflection of the bridge-floor, the non-uniform distribution of forces, and the development of corrosion; further on, he examined how the allowable load of the cables should be assumed with respect to the fact that the tensile strength of the cables would decrease with the time.

Professor Kherndl examined in detail the advantages and disadvantages of suspension bridges, arch bridges, combined arch and cable bridges, girder bridges and three-span girder bridges in his report.

He took part in the reconstruction of the old Chain Bridge, too, in Budapest (1913–1915) as the first official in charge of reconstruction at the Council of Public Construction and he exercised a decisive influence not only on the determination of the general layout of the steel structure but also on the design of the individual main structures. Kherndl finished the examinations and calculations in 1892. The lack of the adequate stiffening girder was especially a problem of the old bridge structure. At the time of Chain Bridge construction, the statics of bridges had not been developed yet which could provide opportunity for the conscious design of a perfect stiffening girder. Clark W. Th. intended to ensure the rigidity in an empirical way. Kherndl stated stiffening of the Chain Bridge in Budapest was relatively the best among the contemporary chain bridges.

In spite of all its observable deficiencies, the original Chain Bridge wore well because it was in service over 66 years, so it fulfilled its duty. The main problem of the re-building was the design of a new stiffening girder, which could be constructed on the basis of the theory of Kherndl.

His unrivalled knowledge, sharp judgement and full objectiveness helped him to get the leading role both in the Hungarian and in the international committees, and his word was always decisive.

Quarter of a Century between the Two Wars

Curriculum Vitae of János Kossalka (Fig. 6)

János Kossalka was born at Vajdahunyad on 19 March 1871 (*Fig. 6*). He was granted his diploma as an engineer in 1893, and he was an assistant to professor Kherndl between 1893–1896. On the commission of the Board of Religion and Public Education, he made a study tour abroad as a holder of state scholarship between 1896–1898. In 1898, he entered into service of the MÁV from where he was assigned to the Ministry of Commerce where he was appointed technical chief counsellor in 1911. In 1903, he was among the first engineers to receive the degree of doctor technicus (dr. Techn.), in 1906 he became privat/associate professor and in 1916 professor of bridge/construction engineering at the Technical University of Budapest. Thereafter, he gave lectures at the University till his retirement in 1941, and beside this scientific and design activity, he played a great role in the public life, too, thus e. g. he was a member of Parliament for several years, as well as the president of the Chamber of Engineers. He died in 1944.

Scientific Activity of Kossalka

In the spirit of his great predecessor professor Kherndl, he performed excellent work mainly in the field of technical sciences. In 1920, his first work 'Statics of structures' was published. In this work, he deals with the forces of the statically determinate plane structures which are induced by permanent load. He introduced both graphical and analytical procedures underlining the ones which give the result in the simplest way. He solves the problems of statics for a general case which can easily be applied to individual cases in practice.

The work mentioned above is destined to meet the demands not only of the students of the Technical University but also those of engineers in employment. He worked out a lot of numerical examples. The work was excellent in every respect and was rewarded with golden medal by the M. M. and É. E. (Society of Hungarian Engineers and Architects) in 1921. His principal work, the 'Statics and Kinetics of Structures' was issued in 1941. According to the original plan, this was meant to be the second volume of the 'Statics of Structures' which was planned to deal with the statically undetermined structures and the effects of moving load. This requires the knowledge of kinematic laws which had not been elaborated so far in such a systematic order than those of statics.

Later on when he set to work out systematically the laws of kinematics, *he realized that each law of statics corresponds to an analogous law of kinematics.* He deals with this analogy in detail. Therefore, he describes again the fundamental laws of statics in order to compare them to those of kinematics. In this way, instead of the second volume of the 'Statics of Structures', a separate book was compiled: 'Statics and Kinematics of Structures'. Dr. János Kossalka developed further the kinematic method designed for examining the statically undetermined beams by generalizing it for beams on elastic supports, statically and kinematically undetermined beams (*Fig. 7*).

This procedure is called the *method of nodal forces*. Kossalka states that the procedures which produce effect in statics are identical with those which help to determine external motions in kinematics. And vice-versa, the procedures which produce effects in kinetics are identical with those which help to determine internal forces in statics.

From these relations between statics and kinetics, the reciprocity law of force and displacement can also be recognized directly without using the laws of imaginal work.

In these examinations the individual bars are represented only by lines on which the internal forces are arisen by external forces in statics, while external motions are produced by internal ones in kinematics. The

Fig. 6. János KOSSALKA 1871–1944)

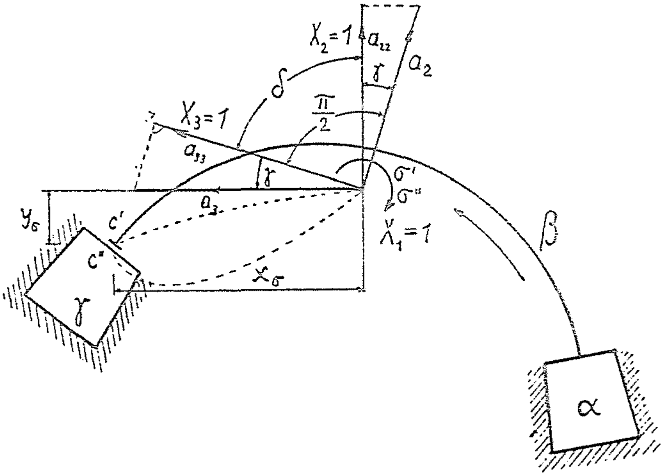

Fig. 7. Beams on elastic supports

analogy of the laws of statics and kinematics is expressed by the equality of external work with internal work assumed from forces and motions on this configuration.

This book of Kossalka contains a lot of witty ideas which are indispensable factors of the modern progress. It is regrettable that this work has not drawn yet the attention of a wider range of the scientific circles.

Scientific Works of Kossalka

1. *Railway Bridge in Szeged* (M. K. 1904). His doctoral dissertation deals with the examination of forces acting on the old railway bridge in Szeged. Several insufficiencies of the structure are detected, and an attempt is made to light the very complex role of the forces acting on the main girders.
2. *Theory of the multi-span frame* (M. K. 1905). The theory of multi-span arched frames had not been dealt with even in the literature issued abroad at that time. The solution given to this difficult problem promoted the development of frames.
3. *Analytical determination of the internal forces of continuous beams* (M. K. 1915). In this paper, he introduces a new procedure allowing the direct, analytical determination of the internal forces arising in the continuous beams with uniform cross-section resting on fix supports — without the use of equations. Finally, he demonstrates how to determine the internal forces arising from the vertical displacement of supports.

Dr. János Kossalka performed pioneering work in the field of bridge-theory and statics, on the one hand, and the bridge construction, on the other. His works are characterized by self-opinionated, original ideas. His fundamental literary activity is imbued with real scientific spirit displaying, at the same time, a comprehension of the difficult problems of building practice.

The Engineering Works of Kossalka

Similarly to his pioneering activity in theoretical field, his activity in creative work was also very productive. The bridge at Dunaföldvár designed by him was the first highway bridge in our country whose main girder was a continuous, multi-span truss.

By the construction of this bridge, the hegemony of the simply supported beams was overthrown, and the fact was confirmed that the disadvantages of the continuous, multi-span beams are smaller than its advantages. The design work here is undoubtedly more time-consuming than that of the statically determinate beams. Besides, disadvantageous stresses may arise due to the depression of supports and the change of temperature.

On the other hand, the actual safety of the statically undetermined structure generally is greater than the calculated with the plastic deformation taken into consideration.

The continuous, multi-span beam is more rigid, its deflections are smaller, its bending moments are smaller, too, and thus the cross-sectional areas of the beam are also smaller and the weight of the beam is lighter.

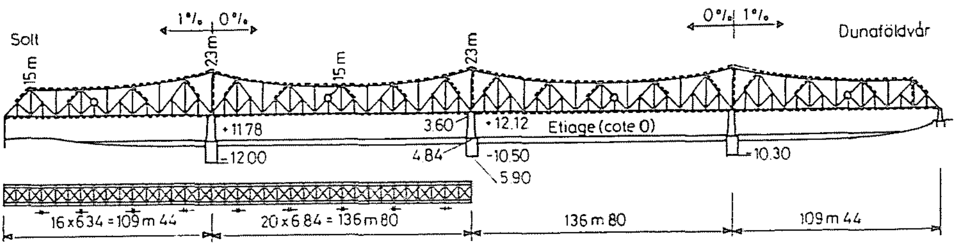

Fig. 8. The Bridge at Dunaföldvár

At the piers of the bridge at Dunaföldvár, a device was applied to detect the accidental depression of the support and it can be repaired accordingly. The assumed depression of support was about 30 mm at this bridge. The bridge is a four-span one (*Fig. 8*). The intermediate span is 133.2 m, while the end one is 106.8 m long. The main girder is a subdivided panel truss. The bridge is a highway-railway one. The height of the main girder is 15 m, above the piers it is 23 m, which is an extraordinary height. The road is 5.51 m wide, side-walks are 1.5 m wide (Kossalka, 1935).

Because of the long spans , the steel structure was made of high/tensile steel, particularly silicon steel. However, this was found unsuitable for this purpose, the material proved to be too brittle (rigid), therefore it was not used any more.

His suspension bridge plan submitted to the invited tenders for the construction of the bridge at Boráros Square was excellent and it was awarded the first prize.

His competitive design of the bridge at Óbuda won half of the contracted prizes I and II. After the competition he was commissioned to do the preliminary design work of the Árpád bridge. His studies covered a large scope of investigations lasting for two years. Various plans were worked out in detail. This preliminary work took place in the framework of a social-emergency action. A number of unemployed engineers took part in this work, among them engineers who were neither structural nor bridge engineers. They were offered an opportunity to acquire some knowledge in bridge construction under the guidance of professor Kossalka, which knowledge was used later in the reconstruction of bridges.

Kossalka as a leading figure of the technical sciences in Hungary fought for the acknowledgement and appreciation of engineering work.

Curriculum vitae of Pál Álgyai (Hubert) (Fig. 9)

Fig. 9. Pál ÁLGYAI (Hubert) (1894–1945)

He was born in Szeged in 1894, and died on 27 August 1945. Álgyai was an assistant, assistant-professor, privat-docent to professor Kossalka. As a young man he became the head of the Highway Department, then the vice-president of the Council of Public Utility and Objects of Civil Engineering, and an under-secretary of State, and finally, the successor to Kossalka at Bridge Construction Department No I from 1943 on.

Álgyai was an ingenious and well-trained engineer. The bridge at the Boráros Square is a credit for his exceptional talent. His early tragic death was a great loss of the technical culture in Hungary.

Scientific Activity of Pál Álgyai (Hubert).

1. *Examination of multi-main girder structures stiffened by two wind-bracings and cross bracings* (M. K. 1933). Álgyai publishes a valuable procedure in his paper which solves the problem with sets of equations independent from each other and consisting of 5–5 equations with 5 unknowns. According to this procedure, the load distribution effect of cross bracings could be taken into consideration, which means a considerable progress.
2. *Approximate calculation method of subsidiary stresses for trussed girders* (Technika, 1934). In the surroundings of gusset plates, the inertia moment of truss members is increased considerably due to the structural layout, and this should be taken into consideration, first of all, in the case of relatively short truss members. Álgyai demonstrates a simple approximate calculation method and assumes that the inertial moment of the bar end is changing according to the hyperbolic law from the edge of the gusset plate to the end of bar. He proves the validity of his assumption by his measurement results obtained with the examination of bridge structures.
3. *Displacements of Beams* (Műegyetemi Kiadó, 1943). A considerable part of Mr. Álgyai's activity is connected to the determination of the displacement of beams. In addition to the strength analysis, he underlines the analysis of displacements. He draws the attention to the examination of the displacements during the assemblage, as well as to the importance of load test prior to putting the supporting structures into service, since one of the most important checks will be provided by the comparison between the actual displacements measured on the beam and the theoretically calculated values.
4. *Bau einer neuen Donau-Strassenbrücke in Budapest* (Bautech-nik, 1934). Mr. Álgyai reports on the problems connected to the design and construction of the bridge at the Boráros Square.

The Engineering Objects of Mr. Álgyai.

The bridge at the Boráros Square was constructed by the Highway Bridge Department of the Ministry of Commerce; the designer of the bridge was Pál Álgyai (Hubert). The bridge is a continuous multi-span structure with four main girders (*Fig. 10*). The lengths of spans are: 112 + 154 + 112m. The road is 15.7 m wide, and the side-walks are 3.5 m wide. The main girder is stiffened by columns with strut bracing. At the place of each column, the main girders are connected by strong cross bracings. In addition, there are

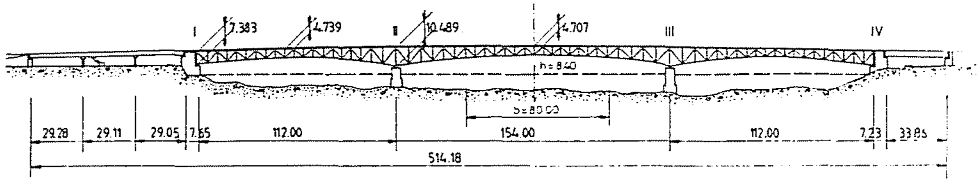

Fig. 10. Budapest; Bridge at the Boráros Square

upper and bottom sway bracings mounted on. The cross bracings stiffen the main girders and wind bracings strongly and distribute the load. The bridge was finished in 1937. (Álgyai–Hubert, 1934).

The Second Half-Century

Curriculum vitae of Imre Korányi (Fig. 11).

Imre Korányi was born on 18 January 1896 at Máramarossziget. He graduated at the Engineering Department at the József Technical University, and was granted his diploma in 1917. He got the degree of dr. Techn. in 1927, and was qualified as a privat-docent in 1937. He got scientific degree of the doctor of technical sciences in 1955.

From 1917, he was an assistant lecturer, then soon an assistant professor at Bridge Construction Department No I at the Technical University of Budapest. In 1926, he changed, he was employed at the Bridge Department of the MÁV Headquarters first as a chief engineer, then from 1943 on as a chief counsellor.

His services in the field of bridge construction were recognized by the head of State in 1947, then in 1950 he was awarded the V. degree of the Order of the Hungarian People's Republic. In 1955, he was awarded the Kossuth prize in recognition of his activity in the field of building and transport, while in 1986 the golden degree of the Order of Labour was conferred on him.

Between 1926–1945, the main field of his activity was the bridge construction, at the Bridge Department of the MÁV he designed bridges and checked the manufacture and construction of steel bridges designed by himself. He was the designer of several modern bridge reinforcements among others, the reinforcement of the railway bridge over the Danube at Újpest, and the bridge over the canal Sió at Szekszárd.

He was granted the diploma of associate professor on the speciality: 'Reinforcement and re-building of steel bridges'. In this meantime, as a building engineer he carried out his designs drafted at the Bridge Department of the MÁV: the main stations of this constructional activity were: Sárvár, Győr, Hegyeshalom, Kunszentmárton, Csongrád and Tiszafüred.

On 8 May 1945, he was appointed deputy-professor at the Faculty of Civil Engineering at the Technical University, and on 22 May he was appointed professor at the University, and was put in charge of Bridge Construction Department No I, which duty he performed till his retirement in 1959.

Between 1945–1959, he displayed a significant teaching and research activity at the Technical University of Budapest, and later on, at the Technical University of Building Engineering and Transportation. In addition to his teaching activity at the University, he took part in the guidance of the reconstruction work of the blown-up bridges (bridges over the Tisza at Algyő, Csongrád, Szolnok, and the bridges over the river Danube at Baja and in Budapest), afterwards he took part in the design of the major bridges. In 1948, he sets about one of his most considerable activities, i. e. the re-writing of the old Railway Bridge Regulations.

After he had finished the Bridge Regulations, he started to write books for University students. These are: 'Statics of Beams', 'Steel Structures'. Through his books and lectures, he furnished a great number of engineers with thorough knowledge in statics of structures.

After retiring, he continued to deal with the design problems of bridge construction till 1975 when he was 80 years old, and he worked at the Bridge Department of the UVATERV. During the period between 1959–1964, he was the member of the experts' committee for drafting the designs of the Erzsébet bridge. Meanwhile, he wrote his book: 'Stability problems in engineering practice' issued by the 'Akadémiai Kiadó' (Publisher of the Academy) in 1965, and he was awarded a special prize for his work of high standard in 1966.

He had amblyopia in 1966, he underwent several operations for his eyes, nevertheless he was working during this period, too, till his retirement in 1975.

In 1987, the degree of honorary doctor was conferred on him by the Technical University of Budapest.

He died on 28 January 1989 at the age of 93. The significance of his activity performed over six decades as covering the scope of engineering, training and research lies in the fact that he relied on profound scientific reflections and procedures in giving solution to the problems occurred in engineering practice.

Fig. 11. Imre KORÁNYI (1896–1989)

Railway Bridge Regulations

In the new Railway Bridge Regulations issued in 1951, a new method was introduced for the calculation of the bridges. The point is that instead of the calculation method based on the permissible stresses, a new kind of calculation with the so called limit-state was adopted as a development of the ideas elaborated by the Danish Moe, which method takes into consideration the standard deviation of the material grade indexes and of the load. The standard established for calculation of railway bridges became the basis of the set of inland design concepts but it was considered as a pioneering work even in international relation. Under the influence of this new method, the calculation principle with the so called limit-state was adopted as a basis of calculation by several countries or international regulations, respectively.

As a first step in this calculation practice, the procedure of uniform factor of safety was developed (which is sometimes called the procedure of allowable stresses). It demonstrates the fact that the current expectable value of the maximum of state parameters — which according to the prevailing standards is called the basic value (F_k) of those — should not exceed the magnitude of the normative value of the limits as divided by the uniform safety factor γ_u, i. e. the permissible value R_p of the limits (allowable load, allowable internal forces, allowable stresses, allowable deformation, etc.):

$$F_k \leq \frac{R_n}{\gamma_p}; \qquad F_k \leq R_p.$$

The procedure of load and resistance factor (which is sometimes called the procedure of limit stresses) starts from the fact that statistical data (though they are incomplete and are related, above all, to the different loads and to the properties of material separately) can be used in a better and more economical way in case of the standard deviation of state characteristics (loads) and that of their limits depending strongly on the material properties are expressed by separate factors of safety (though with extra calculation work), as follows:

$$\gamma_F F_k \leq \frac{R_k}{\gamma_m} = R_L$$

where R_L stands for the limit-value of limits: (limit load, limit internal forces, limit stress), while γ_F is the factor of safety for load, and γ_m is the safety factor for the corresponding limit (*Fig. 12*).

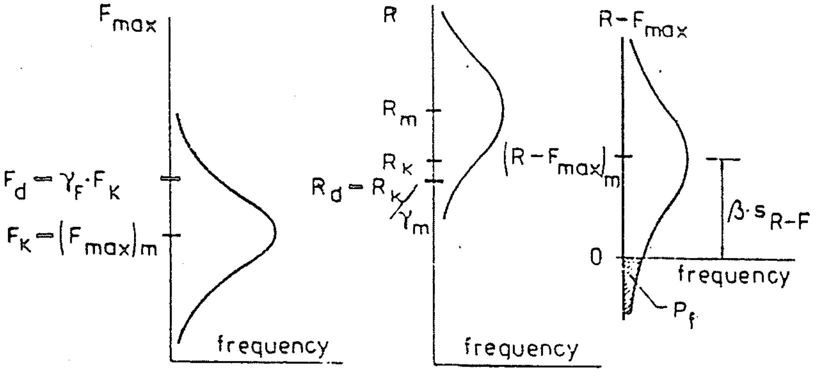

Fig. 12. The allowable stress and limit-state methods

By introducing the designing procedure of load and resistance factor, the traditional interpretation of safety was discarded by the introduction of this Regulation (first in Europe); in relation to bridges, this Regulation was the first to apply the designing procedure of load and resistance factor and the concept of limit stresses due to which, it undertook a pioneering role in the modernization of the dimensioning method used with the engineering structures.

Professor Dr. Imre Korányi founded a school through the elaboration of the design regulations; the members of this school worked out the regulations related to the dimensioning of steel structures by applying the methodical and technical principles initiated by him over the past decades.

Engineering Objects Established by Korányi

At the Bridge Department of MÁV, he was engaged in designing bridges and controlling the manufacture and construction of the steel bridges designed by himself. At the Bridge Department, there was a useful custom, one bridge was designed only by one engineer from drafting the general plan through static calculations to the detail drawings. Then the plans were given to another engineer who performed the check of calculations on the basis of the plans, as well as the detail drawings down to the last dimension number. Subsequently, the designer took over the matter, and he controlled and checked, respectively, — from the reception of the material as far as the realization of the load-test — the manufacturing processes, the construction and assemblage of the bridge, including even the occasional contractor's work. In this way, the MÁV brought up a staff of trained, excellent bridge-construction engineers for its purposes. It was due to this fact that the construction of bridges for the railway lines of Transsylvania, then the reconstruction of the railway bridges blown up in 1945–1948 could be carried out without any interruption.

Imre Korányi also took an active part in these jobs, especially in the field of the reinforcement of steel bridges. The ever increasing permanent railway loads and the weight of locomotives had led to the negative result that the load-carrying capacity of the bridges designed for ideal load assumed with great care had turned inadequate, and due to it, the bridge in question either had to be replaced by a new structure, or — what was a relatively easier and in many cases a cheaper solution to the steel structures — it had to be reinforced with new flange plates etc. riveted on. The period before the Second World War was when the necessity of this kind of reinforcement of steel bridges developed into a separate branch of sciences especially during the period between the two world wars with literature comprehensive enough. Korányi planned several great, original bridge reinforcements (railway bridge over the Danube at Újpest, bridge over the canal Sió at Szekszárd), which he described in literature, too. On the basis of those, he was invited by the Council of the Technical University, to give a lecture as a privat-docent without prescribing a colloquium, which he delivered on 9 February 1937, its title was: 'Welding used for the reinforcement of steel bridges'. As a result, he was granted the diploma of privat-docent (Decretum habilitationis) on the subject of 'Reinforcement and Re-building of Steel Bridges' on 27 April 1937.

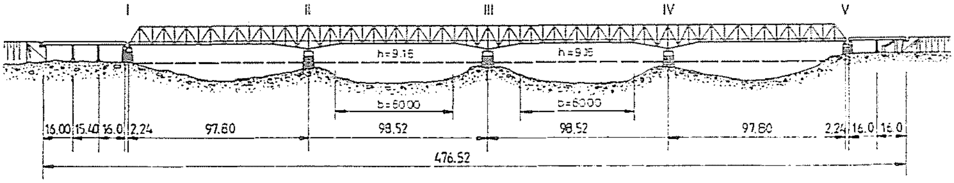

Fig. 13. Budapest; Southern Railway Bridge

On 22 May 1947, he was appointed professor at the University, however his relations to the MÁV were not interrupted; he took part in drafting the designs of the major bridges, among others, the design of the steel construction of the Southern Railway Bridge over the Danube. The Southern Railway Bridge was reconstructed not in its original shape as a trussed arch-bridge with tie-rods but as a continuous, four-span trussed main girder with a single track. The length of the intermediate spans is 98.32 m, while the length of end ones is 87.8 m. (*Fig. 13*). (Korányi, 1948). In 1949, he leads the design work of the bridge over the Danube at Baja. This bridge also was reconstructed as a structure deviating essentially from the old one. The former simply-supported main girders of 100 m in length were replaced by continuous multi-span girders. The cross-girders are connected rigidly to the main girder, and besides, they ensure the possibility of a cantilever-like elongation for a highway bridge to be constructed on both sides. (The insertion of the cantilever took place in 1990, the members of the Department of Steel Structures took an active part in the job).

The Books and the Scientific Papers Compiled by Korányi

1. *Statics of Beams. Volumes I–II* (Tankönyvkiadó Vállalat, 1953–1954)

A text-book in which the corresponding parts of mechanics are assumed known, it leads the learners step by step to the cognition of statics in a logically arranged order. His work displays his qualities as an experienced teacher who is aware of the problems of his students throughout, and tries to light the details which seem difficult to understand for the students.

This book proved to be a reliable guide-line for the engineers engaged in construction, too. It offers more than covered by the lectures given at the Technical University, according to the demands of practice. Though it is only a text-book, nevertheless the question arises whether it contains any new pieces of information, and whether it contributes to the progress in sciences. One is the method of discussing the influence of shear forces on the deflection of simply supported beams, while the other problem is: how to construct the deformation diagram of solid wet girders with work-equations. In addition, here can be mentioned the general summary of the influence line, and the use of it, which cannot be found anywhere else in such a form.

2. *Steel Structures* (Tankönyvkiadó Vállalat, 1960)

As a text-book, the introductory part can be considered a success, in which he first enumerates briefly the fields of application — in many cases a proprietary application is in question — , then he describes the procedure of the steel production and refinement, as well as the material structure of steel.

It is useful that the author described — in spite of the wide extension of the subject — the processing machines and tools of different operations (rolling, drilling, riveting, welding) at the processing and joining of the structural steel elements, and by doing so, he established direct connection between the theoretical principles discussed in his book and the practical work of their realization.

In the discussion of each theme, he has an eye to the latest results, and even to the trend of the development. The parts dealing e. g. with the pre-stressed bolted joint, welding, composite constructions, tube constructions, buckling, etc. resulted from a consideration of such an aspect.

Numerical examples can be found in each chapter.

However, the content of the text-book exceeds its framework, and can be used as a handbook, too. The author wanted to serve the demands of the engineers engaged in construction, and therefore gives a list of the relevant technical literature at the end of each chapter. For similar reasons, he touched — as far as possible in detail — the types of beams under development presently (pre-stressed bolted joints, composite constructions, welded joints).

3. *Problems of stability in engineering practice. Buckling in plane* (Akadémiai Kiadó, 1965).

This book is the first comprehensive work in Hungarian language on the stability problems of engineering structures. The effort for a more economical construction is aimed, first of all, at the economy of structural material and the reduction in the cross-sectional area, and above all, in thickness dimensions of the supporting structures, but at the same time — for a better utilization of space — increasing the spans of the bridging structure are necessary. This two-way development leads to the slenderness of the structure, and as a consequence, to the indispensable recognition of stability problems. Thus, it is not only a mere chance that the works covering the wide range of this problem are issued abroad dealing with both the stability theory and the solutions to the problems. As in the title of the book is referred to, it is destined to provide help for the engineers engaged in the design of structures by furnishing them with the ability of giving practical solution to stability problems. However, the execution of this objective, in turn, rendered it indispensable to explain the principle of stability theory on a required level. The author solved the problem of amalgamating the theory and practice successfully. Professor Korányi performed an exceptionally wide and extensive scientific activity of publishing books, the list of technical literature compiled by him contains the titles of 122 papers.

Curriculum Vitae of Ferenc Szépe

He was born on 6 February 1923. After the retirement of professor Imre Korányi, Ferenc Szépe so far an associate-professor was appointed the head of the Bridge Construction Department No I, which commission expired in 1968. He presently works as an active member of our Department. The denomination of Bridge Construction Department No I was changed into 'Department of Steel Structures' in 1962.

Curriculum vitae of Ottó Halász (Fig. 14.)

Ottó Halász was born in Budapest on 24 October 1927. After the trouble some times of war, he performed his university studies at the Civil Engineering Faculty of the Technical University of Budapest from where he graduated and was granted his diploma in 1950. Subsequently, he took part in the work of the Department of Bridge Construction No I (presently the Department of Steel Structures) as an assistant. He started his scientific career as an aspirant for Candidate's degree, at the end of which he was conferred on the degree of Candidate in Technical Sciences in 1955.

He became doctor of technical sciences in 1976. The Hungarian Academy of Sciences elected him a corresponding member in 1983.

He was the president of the Special Committee of Construction and Transport of the Academic Degree Committee for over a decade. He made considerable efforts to acquire an international reputation for the inland scientific life and results, and with this in mind, he initiated and organised several international conferences to be held in our country.

Fig. 14. Ottó HALÁSZ (1927–1986)

In recognition of his scientific activity, he was elected a member of several international scientific associations, among others, e. g. :

— the 'International Society of Bridge and Structural Engineering' (he was the president of the National Committee of this Body),
— the 'Structural Stability Research Council' in the United States elected him a corresponding member,
— the 'Committee of Mechanical Problems' established by the Academy of Sciences in the Eastern European countries elected him a member,
— he was the honorary doctor of the St. John's University of New York.

He trained the civil engineers' generations the knowledge of bridge- and structural engineering for over three decades, and established a school of followers in the field of scientific post-graduate education, and he was the tutor of a number of candidates. As a university professor, he was the head of the Department of Steel Structures at the Technical University of Budapest over two decades without any interruption, where he performed a pioneering work in the field of bringing the technical training to an up-to-date level.

He was the Dean of the Faculty of Civil Engineering for 11 years with some years interruption.

He died on 14 February 1986. He was working even during the last weeks of his life in spite of his illness, and controlled the operations to preserve the Szabadság bridge in Budapest for the posterity.

Scientific Career of Ottó Halász.

The scientific activity of Dr. Ottó Halász gave solution to several theoretical and experimental problems in the field of engineering mechanics. His scientific activity was mainly directed to the following three fields: theory of plasticity, theory of stability and analysis and design of structures. He achieved considerable results in each field separately, however, it should be noted by way of introduction that his activity is characterized mainly by the joint discussion of these fields, i. e. by scientific synthesis.

He began his scientific career like a 'comet' when he presented the most important results of his candidate's dissertation to the most outstanding representative of the contemporary theory of structures, professor V. Z. Vlaszov who mentioned these results appraisingly, and published his practically first paper in the periodical of the Soviet Academy of Sciences. His paper: 'Limit State Equilibrium for Reinforced-Concrete Plates' is considered as a fundamental work. In this paper, he applies one of the basic principles of the so- called theory of limit-state equilibrium serving for the determination of the load-carrying capacity of structures to the case of reinforced-concrete plates. This basic principle was: if the load distribution is permanent and the monotonous increase of the multiplier parameter of the basic load, then the failure parameter of the multiplier belonging to the failure can be calculated merely with the knowledge of static equations and the specific ultimate moment. The failure parameter is identical with the greatest multiplier of the basic load for which a statically still possible load distribution can be found within which the solution to the extremism problem contained in the basic principle was demonstrated for the cases of the specific moments and the two-way plates of uniform reinforcement.

His work in connection to the examination of the plastic load-carrying capacity of steel structures is significant. His name is associated with the statement of numerous theoretical principles, and the elaboration of a number of practical design procedures, among others, the generalization of Shanley phenomenon, with which the scientific world was acquainted first in connection with the buckling of compression members. He proved that the bifurcation of equilibrium may happen in the case of stable equilibrium due to the non-unequivocal behaviour of the plastic hinge. By applying square programming, he also demonstrated the examination of the plastic load-carrying capacity of second-order frame structures (loaded by great

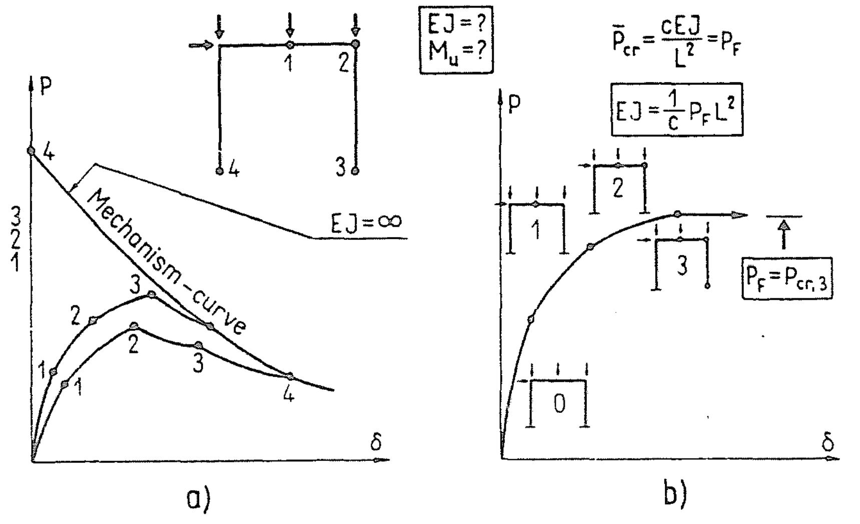

Fig. 15. The concept of relatively rigid model

compressive forces). He introduced the concept of the so-called relatively rigid structures, with which the exhaustion of the plastic load-carrying capacity occurs after the occurrence of yield mechanism developing on the basis of the first-order theory (*Fig. 15*). The classification of this type of frame structures is important with respect to the plastic design of frame structures.

The formation of the first inland standard in relation to plastic design of steel structures is also connected to the name of Dr. Ottó Halász. In preparation of this standard, he used the results of the significant experimental work performed jointly with his colleagues-researchers, which make the structures designed on the basis of the theory of plasticity not only economical but safe in design at the same time.

As early as the early stages of his research activity, he was interested in the problems of the theory of stability, in particular, the hardly recognizable phenomena of stability of the thin-walled structures. His name is connected to numerous theoretical and practical achievements. The chapter dealing with the statical problems in the comprehensive book on thin-walled bars is authoritative for the engineers even today. The procedures applied to the design of thin-walled steel structures, the reckoning with the initial inaccuracies, curvatures are also connected to his name. In the field of construction of light-weight structures, both the problems associated with the application of different metals (high-tensile steels, aluminium), and the development trends of construction industry were always in the focus of his attention. His examination connected with the buckling of plates was inserted into several design standards, among others, into the Railway and Highway Bridge Regulations.

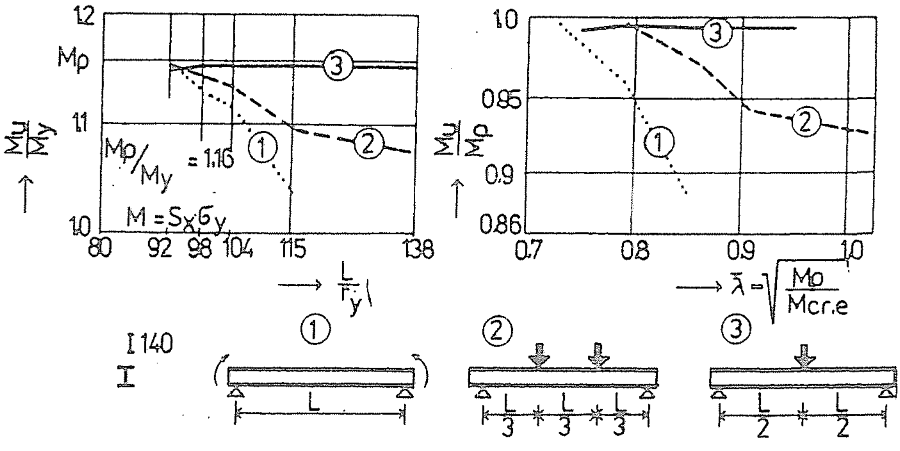

Fig. 16. Effect of the shape of the bending moment diagramm

His results achieved in the field of stability examinations are kept in evidence in international relations, too. Thanks to this fact, he was invited to take part as a lecturer at numerous international colloquiums and conferences dealing with this sphere of themes. Only one example from them: on 11–15 May 1981, he gave a lecture on the problem of the lateral buckling of beams on the basis of his examinations at the Conference of the American Society of Civil Engineers held in New York (*Fig. 16*). He detected the causes of deviation of the different design regulations from each other, in particular, the decisive role of ideal and imperfect models. The classification sketched by him became generally accepted in the international technical literature.

He pursued a significant activity as a research organizer, too. He participated in the organization of the series of international programs (colloquiums in Tokyo, Washington, Liége, Budapest–Balatonfüred) in 1976–77 arranged for summarizing the results of investigations into stability of metal structures. One of the great achievements of his activity in the field of stability theory was the work: 'Stability of Metal Structures. A World View' compiled in collaboration with authors of several foreign countries (Council of Stability in the USA, European Convention of Steel Structures, Japanese

Council of Stability, and the Steel Structure Committee of the COMECON countries), the general introduction and the arrangement of the chapters dealing with the special technical problems were commissioned to the care of dr. Ottó Halász on the part of the Eastern European countries. His results were acknowledged, among others, also by the fact that the international conference on the 'Stability of Steel Structures' was held in Hungary already for the second time, the organizational committee of the conference worked under the management of dr. Ottó Halász till his death.

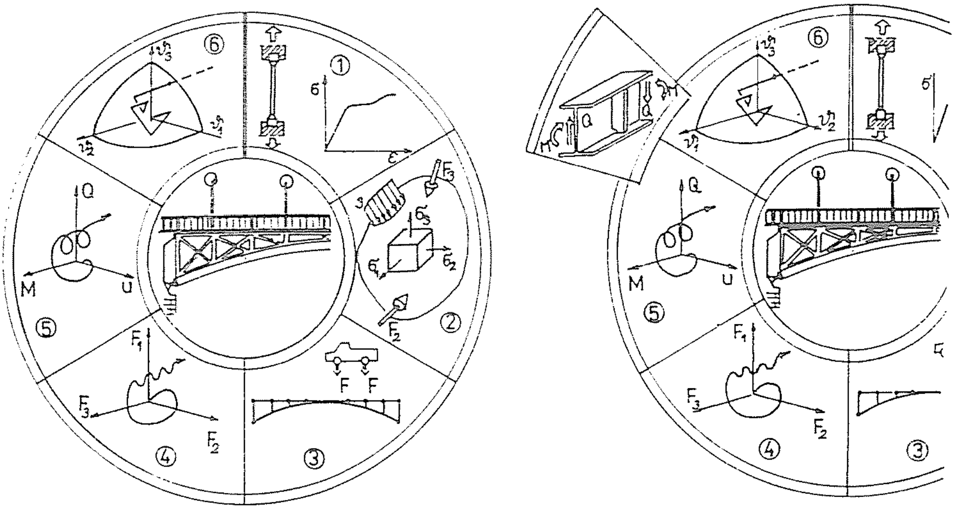

Fig. 17. The concept of 'target model'

The outstanding recapitulation of his results achieved in the field of the calculation theory of structures was contained in his paper on the occasion of his inauguration as a corresponding member of the Hungarian Academy of Sciences. He formulated a number of statements determining the work of researchers addicted to the problems of calculation for a long time in the future, thus e. g. the concept of the so-called 'target model' introduced by him (*Fig. 17.*). When his scientific activity is analyzed, the recognition of the fact should be emphasized that the change in the content of stability examinations occurred during the past decades by the increase in the possibilities of computing technique. His statements connected to the theory of design made by the international colloquiums organized in 1976–1977 were summarized by professor Massonnet who mentioned the name of Ottó Halász as one of the initiators of this process. One of the classical goals of stability examinations is the investigation into the bifurcation of equilibrium. The calculation of the critical load connected to it has a strong relation to the application of the computational models reflecting the earlier limited possibilities in computing technique, which models illustrate the behaviour of the structure by assuming very small deformations and generally elastic material properties, by the often considerable simplification in the geometry of structures, by the limitation of the degree of freedom of displacements, by the exploitation of the possibility of symmetry. More advanced computational models obtained without those constraints — which can contain the geometrical and initial stress data reflecting the actual circumstances of production — can render the separate stability examinations unnecessary: and besides, the loss of stability is considered as one form of the loss of load-carrying capacity, which however, does not assume the interruption of the continuity of the material. Thus the criticism of the applied computational model will be rendered the fundamental question of the stability examination procedure.

During the last weeks of his life, his recommendations for the new standard MSz 15024 related to the design of steel structures was accepted. These recommendations, by building those ideas into the standard, offer possibility of performing the examinations according to the traditional procedure, or else performing the examinations with the use of the so-called 'imperfect model' which is a more advanced one requiring also the application of computing technique, the latter procedure involving the initial geometrical and stress inaccuracies — or the possible variations of those — respectively. In this way, the renewed stability examination can build into the design process the elements which can be developed fully with the use of computing technique.

Books and Scientific Papers of Professor Halász

1. *Structural and Calculation Problems of Bridges with Orthotropic Floor Slabs.* (Mérnöki Továbbképző Intézet = Institution of Continuing Education of Engineers, 1959). (Co-author:Ferenc Hunyadi).

The stresses arising in the floor slab of a large width can not be calculated by the formulae of elementary strength analysis. Therefore, in design practice each stripe of the floor slab — the so-called co-operating width — is considered as an independent flange plate of each girder, and it is assumed in a way that the play-force of the main girder calculated with the help of the methods of elementary strength analysis, and the play-force obtained in an exact way should be identical. The authors assume a hinged joint between the main girder and the floor slab, while they neglect the horizontal rigidity and the rigidity of the main girders, as well as the vertical flexural rigidity of the floor slab. They draw the attention to the fact that the co-operation width depends not only on the geometrical data but also on the ratio of the loads applied to the two main girders. The authors solve the problem for both the isotropic and orthotropic floor slabs, and touch also the case of the floor-slab section overhanging the main girders. The co-operation width of the main girders is given by formulae treatable in a simple way. With orthotropic floor slabs these constants are given in the form of more complex relationships.

2. *Thin-Walled Steel Structures* (Műszaki Kiadó = Technical Publisher, 1965). (The co-authors of the book:Ödön Csellár and Vilmos Réti.)

The book deals with the problems of the design, production, strength calculation and stability theory of thin-walled steel structures. The chapter on torsion deals with the internal forces less known for civil engineers. The calculation of thin-walled bars of open profile required the revolutionary development of the theory of torsion. In the chapter dealing with the problems of stability, a clear and easily understandable explanation of torsion buckling is given, which is a phenomenon hardly found in the technical literature yet. This chapter covers the buckling of members in eccentric compression and those in axial compression, then the buckling plate and lateral buckling of girder. The explanation of the theoretical bases is followed by regulations with respect to design, and the diagrams and tables enlightening the design process. This part of the chapter is of high value because it was just Ottó Halász who made up the regulations related to the stability examination of thin-walled structures in conformity with the stability examination of traditional ones. Those said in this chapter are rendered even more clear by some numerical examples.

3. *Steel Structures* (Tankönyvkiadó, 1987).

In this book, the teaching activity and the experiences gained over more decades by the authors — co-author is: professor at the university Dr. Pál Platthy — are summarized with an impressive compactness replacing officially the book of identical title of Imre Korányi published in 1960. The university text-book deals with the fundamentals of construction and design of engineering steel structures, where the expression 'engineering structures' is related generally to constructions or those individual parts which can be handled separately and fulfil, above all, the function of supporting structures in addition to their special duty.

On the basis of curriculum of subject: 'steel structures', the book contains the following:

— steel structural materials and structural elements,
— the most important information of production and assemblage,

— the principles of calculation, the calculation of beams used most frequently,
— the principles of design, the fundamental constructional solutions,
— the more important regulations for steel structures.

The chapter summarizing the principles of calculation is a very instructive reading for the engineers engaged in practice, too. The theoretical relationship used as a basis in the course of elaborating the regulations for the technical regulations are explained in a didactically understandable way, the author draws the attention to the difference in the methods of approximation and to the changes occurred due to development and the ones still expectable. He displays the characteristics of the Model to be introduced in the course of design (loading process, material, structure), the state parameters determinable by the use of them, as well as the characteristic limit state of the structure. The calculation procedures are enriched by insertion of the plastic-design method of bar structures into the subject-matter of the book. Ottó Halász pursued a very wide-range, extensive preparatory scientific publication activity on the occasion of the international scientific conference to be held in Tihany between 25–27 September 1986, which was held in his memory after his death in the meantime. The works of his literary activity and his several papers were published in a collection 'DOCENDO DISCIMUS' (Editor: dr. Miklós Iványi).

Laboratory for Construction Industry

(It was opened on 15 April 1975) (*Fig. 18.*). He formulated his clear opinion and applied it that one of the key-problems of the design and calculation of steel structures is presently the thorough methodical amplification and systematization of the knowledge connected to the operation and failure of the full-scale, real structures. Without this the pieces of partial information multiplied by the potentialities of computing technique, and the amplification of the possibilities provided by laboratory experiments cannot be synthesized into an integral whole in practice. Therefore, he considered that the measurements performed on real structures, and the observations on the full-scale structures examined in the laboratory should constitute the core of his research, and for the same reason, he considered as his object of life, the establishment of the Laboratory of Construction Engineering as well as the scientific work performed in the Laboratory.

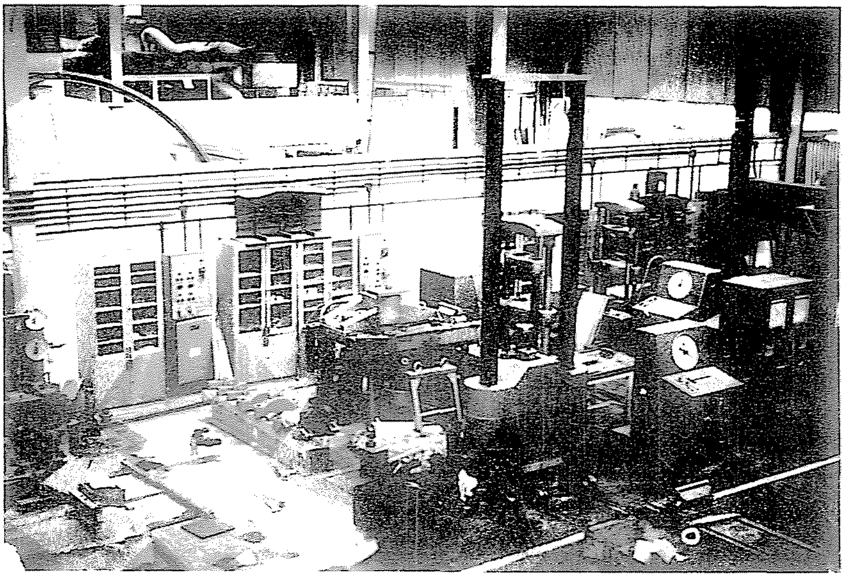

Fig. 18. Laboratory for construction indrustry

Epilogue

But besides the heads of the Department of Steel Structures engaged in construction engineering for steel bridges, the teaching staff and the researchers of the Department also performed and perform presently significant work in controlling, first of all, the design work and calculations, and in the design of original bridge structures as experts of bridge construction. Already at the initial phase of design and later in the course of construction, arose the necessity that the behaviour assumed in the course of static calculation should be compared with the actual force-play and checked by measurements (SZITTNER, SZÉPE 1987–1988).

The measurements performed on small-scale models at the stage of design, and later, on the real structure itself, can be carried out with the help of the methods of the experimental stress analysis, the possibility of which has already been created as a result of the many years activity of the staff at the Department.

Static and dynamic stress and strain measurements, respectively, could be carried out reliably only after the improvement of the resistance strain-gauge, and after the development of measuring amplifiers and the adequate recording apparatuses with the indispensable experiences acquired. The recent development in this field is connected to the adoption of the methods of computer-aided data processing, the computer-processing of the measurement results and computer-aided measurement control. Below, five spheres of themes selected are from among the numerous activities of the Department, each illustrated by the example of a bridge over the Danube, as follows:

— preliminary experiments performed for the design of bridges: examination of the force-play of the assemblage at the Erzsébet-bridge in Budapest (SZITTNER, 1965)
— checking the force-play by experimental methods in the course of examining the constructional-technological processes of the bridge: determination of the phases of assemblage with the bridge over the Szentendre-Danube at Tahitótfalu, and that of the deformations caused by the effect of welding (KÖRÖNDI, KRISTÓF, PLATTHY, SZITTNER, 1979)
— realization of load-test prior to opening the bridge to traffic: examination of the orthotropic floor-slab of the highway bridge called the Árpád bridge (SZATMÁRI, 1982)
— state-determination of bridges: examination of corrosion occurred in the eye-bars of the Széchenyi Chain Bridge (SZITTNER, 1990)
— detection of the causes of bridge catastrophes, contribution to the realization of the possible reconstruction: expertise in connection with the Szabadság bridge (SZITTNER, 1987).

Naturally, the experiences gained in the field of steel-bridge construction were inserted into the subject-matter of training, and the experiences were made good use of in the fields both of laboratory work, and in compiling the diploma project, as well as in the field of postgraduate training.

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