

Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH
Kongressbericht

Band: 12 (1984)

Artikel: Towards a unified comprehensive system in design of reinforced and prestressed structures

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DOI: <https://doi.org/10.5169/seals-12245>

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TOWARDS A UNIFIED COMPREHENSIVE SYSTEM IN DESIGN OF REINFORCED AND PRESTRESSED STRUCTURES

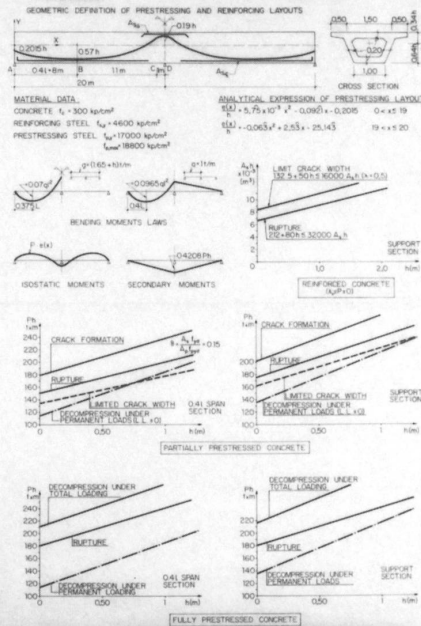
1- INTRODUCTION

- LIMIT-STATE METHOD APPEARS ALREADY IN MANY REINFORCED CONCRETE STRUCTURES CODES AS A PHILOSOPHY OF DESIGN
- MORE RECENTLY, PRESTRESSED CONCRETE STRUCTURES CODES HAVE ADOPTED THIS DESIGN PHILOSOPHY
- HOWEVER, CURRENT DESIGN PROCEDURES MAKE A SEPARATED TREATMENT OF REINFORCED AND PRESTRESSED CONCRETE STRUCTURES
- WHAT ADVANTAGES ARE THERE A PRIORI IN A UNIFIED DESIGN TREATMENT?
 - MORE CONSISTENCY IN CODES
 - SYNTHETIZATION FOR TEACHING PURPOSES
 - OPENING OF A NEW PERSPECTIVE FOR FUTURE ACHIEVEMENTS IN THE CONCEPTION AND DESIGN OF CONCRETE STRUCTURES
- THE IDEAS DEVELOPED HERE ARE INCLUDED IN A TREND OF RESEARCH IN WHICH REINFORCED CONCRETE COULD BE UNDERSTOOD IN THE FUTURE AS A SINGULAR AND LIMIT CASE OF PRESTRESSED CONCRETE, BEING $P=0$

2- METHODOLOGY

- IN PRINCIPLE ONLY CONCRETE STRUCTURES COMPOSED BY LINEAR ELEMENTS WILL BE TREATED HERE
- CROSS-SECTIONAL SHAPE IS FIXED A PRIORI IN DESIGN, DEPENDING MAINLY ON ECONOMICAL CRITERIA (I.E., CONSTRUCTION) RELATED TO BOTH REINFORCED AND PRESTRESSED CONCRETE TECHNIQUES AND OTHER GENERAL STRUCTURAL AND FUNCTIONAL FACTORS
- IN ADDITION, ANOTHER PRIOR PARAMETER CAN BE THE RELATIVE POSITION OF LONGITUDINAL STEEL INTO CROSS-SECTIONAL DEPTH OR, BETTER, THE SHAPE OF REINFORCEMENT AND PRESTRESSING LAYOUTS
- FURTHERMORE, THERE IS AN SPATIAL CORRELATION BETWEEN PRESTRESSING FORCE P VALUES (FRICTION LOSSES) DEPENDING ON THE CONTINUITY OF TENDONS
- STARTING FROM THAT THERE IS A SET OF DESIGN PARAMETERS
 - h , CROSS-SECTIONAL DEPTH, CONSTANT
 - A_p , PRESTRESSING STEEL AREA OR VARIABLE (ALSO A PRIORI DECISION) ($A_p=0$, R.C.)
 - P , PRESTRESSING FORCE ($P=0$, R.C.)
 - A_s , MAIN LONGITUDINAL REINFORCEMENT AREA
 - b , WEB WIDTH
 - A_{st} , TRANSVERSAL REINFORCEMENT AREA
 - d , FLANGE WIDTH
- AMONG THESE PARAMETERS, IT SEEMS USEFUL TO OUTLINE h , A_s , A_p AND P .

3- EXAMPLE



2- (Cont.)

- DIRECTLY LINKED TO BENDING, AS THE MOST SUITABLE REGARDING THIS WORK.
- ON THE OTHER HAND, A NUMBER OF DESIGN CRITERIA, SUCH AS ECONOMY, DURABILITY, AESTHETICS AND, IN GENERAL, THE LIMIT STATES MUST BE SATISFIED
- LIMIT STATES VARY FROM ONE CODE TO OTHER, IN GENERAL THE FOLLOWING CAN BE INCLUDED:
 - ULTIMATE LIMIT STATES:
 - EQUILIBRIUM RUPTURE (BENDING, SHEAR, etc.), BUCKLING...
 - SERVICEABILITY LIMIT STATES:
 - DEFORMABILITY, CRACKING, VIBRATIONS.
- AMONG THESE EMPHASIS WILL BE MADE ON THE LIMIT STATES RELATED TO BENDING SUCH AS FLEXURAL RUPTURE, DEFORMABILITY AND, IN PARTICULAR, THE DIFFERENT LEVELS OF CRACKING CONTROL (DECOMPRESSION, CRACK FORMATION AND LIMITED CRACK WIDTH) GOVERNING THE DEGREE OF PRESTRESSING (TOTAL PRESTRESSING, PARTIAL PRESTRESSING AND, IN THE LIMIT, BEING $P=0$, R.C.)
- THE GENERAL CONDITIONS ABOVE MENTIONED ARE LINKED TO THE DESIGN PARAMETERS THROUGH A NUMBER OF RELATIONS USED IN THE ANALYSIS, REFERRED TO THE CRITICAL SECTIONS, SUCH AS
 - RUPTURE $N (K_1 A_s f_{yd} + K_2 A_p f_{yp}) \geq K_3 + K_4 P + K_5 h$
 - DEFORMABILITY $\alpha (f'_{ct}) \geq \delta + \beta P + \gamma h$
 - CRACKING DIFFERENT EXPRESSIONS MUST BE USED FOR THE UNCRACKED STATE IN TERMS OF STRESS AND FOR THE CRACKED IN TERMS OF CRACK WIDTH A GENERAL EXPRESSION COVERING THE WHOLE FIELD CAN BE:
 - $\lambda h (K_1 A_s f_{yd} + K_2 A_p f_{yp}) \geq K_6 + K_7 P + h K_8$
 - IN WHICH λ SHOULD BE ADJUSTED TO COVER ALL POSSIBLE SITUATIONS IN THE CRACKING LIMIT STATES
- OTHER GENERAL RELATION CAN BE STATED $P \leq K A_p f_{yp}$

NOTE: TERM P INCLUDES PRESTRESSING SECONDARY EFFECT. THE VALUES OF THESE DESIGN PARAMETERS ARE FINALLY DETERMINED ACCORDING TO ECONOMIC CRITERIA. FINING IN GENERAL, THEIR MINIMUM VALUES CORRELATE WITH THE DESIGN CONDITIONS IN THE CASE OF THE SIMPLICITY OF THE PROBLEM ALLOWING TO ADD ECONOMIC CONSIDERATIONS (EXPLOITED) IN RELATION SHIP BETWEEN N AND A_s FOR A MINIMUM COST THAT PROVIDE A SUFFICIENT ULTIMATE MOMENT.

4- CONCLUSIONS

- A UNIFIED METHOD FOR THE DESIGN OF REINFORCED AND PRESTRESSED CONCRETE STRUCTURES, BASED IN A JOINT DEFINITION OF RELATED PARAMETERS (h, A_s, A_p, P), GOVERNING BEHAVING HAS BEEN ESTABLISHED STARTING FROM LIMIT STATES CONDITIONS
- THE RESULTS OF THE EXAMPLE ANALYSED ACCORDING TO THAT METHOD ARE LOGICAL, BEING THE MOST REMARKABLE ASPECTS:
 - ONCE THE LIMIT STATES THAT MUST BE SATISFIED ARE PREDEFINED, DESIGN PARAMETERS CAN BE OBTAINED THROUGH THE CONDITIONS ABOVE EXPRESSED
 - THE MORE RESTRICTIVE LIMIT STATES IN THE DESIGN CAN BE IDENTIFIED AS A FUNCTION OF THE STRUCTURAL TYPE, GEOMETRY, LOADING AND DEGREE OF PRESTRESSING FROM R.C. TO FULLY P.C. SO THAT THE REMAINDER LIMIT STATES ARE ONLY FOR VERIFICATION
 - FACTOR λ PLAYS AN IMPORTANT ROLE IN THIS TREATMENT A GOOD DESIGN REQUIRES AN ADEQUATE ELECTION OF λ
- FURTHER RESEARCH IS NEEDED IN ORDER TO SET THE RANGE OF VALUES OF λ ASSOCIATED TO A SPECIFIC LIMIT STATE FOR DIFFERENT CROSS-SECTIONS AND DEGREES OF PRESTRESSING