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Dimensioning of Elements with Built Up Steel Corbel at the End

Dimensionnement d'éléments en béton munis de cornières métalliques à leur extrémité

Bemessung am Auflager als Stahlkonsole ausgebildeter Elementen

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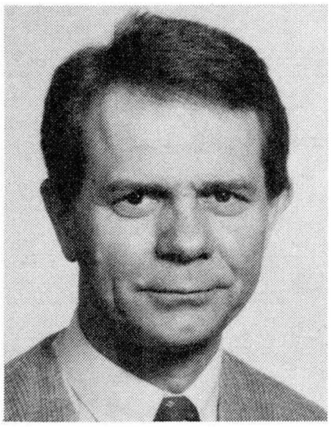


József Almási, born 1940, received his civil engineering degree at the University of Budapest in 1964, and Ph. D. degree in 1972. The focus of his work nowadays is plasticity and detailing.

SUMMARY

The paper reviews experimental work on specially supported elements, where there is discontinuity in geometry and load. It proposes three calculation models: crack free state, cracked state, and strut-and-tie. The determined tensile forces can be followed with a good detailed reinforcement fulfilling the serviceability limit state requirements.

RÉSUMÉ

L'article présente le travail expérimental effectué sur des éléments sur appuis spéciaux, où l'on a constaté des discontinuités dans la charge et la géométrie. Trois méthodes de calcul sont proposées: état non-fissuré, fissuré et analogie du treillis. Les forces de traction calculées peuvent être requises par une armature détaillée assurant les conditions de l'état limite de service.

ZUSAMMENFASSUNG

Der Aufsatz gibt einen Überblick über Versuche besonders gelagerter Träger, bei denen in Geometrie- und Belastung-Diskontinuitäten vorkommen. Drei Berechnungs-Methoden werden vorgeschlagen: Rissefreier Zustand, Riss-Zustand, und Stabwerk-Modell. Die berechneten Zugkräfte können mit Bewehrung abgedeckt werden, die die geforderten Ansprüche hinsichtlich Gebrauchstauglichkeit erfüllt.

1. INTRODUCTION

Structural elements can be used for various purposes if their supporting is solved in an "adjustable" way at the butt end. This is shown in Fig.1 e.g. on a floor-plate element, where on the left side the built up steel corbel has a lower- and on the right side an upper position.

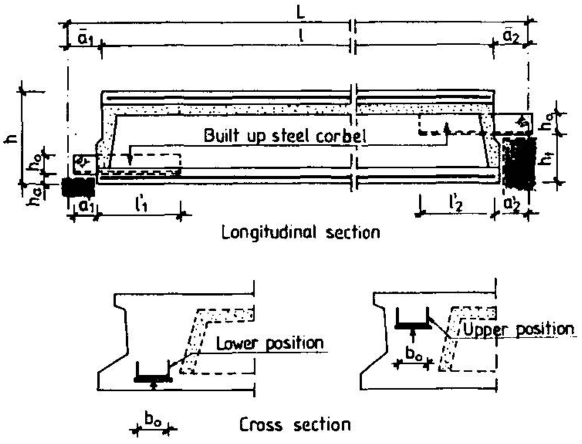


Fig.1 Floor plate element with built up steel corbel at the end

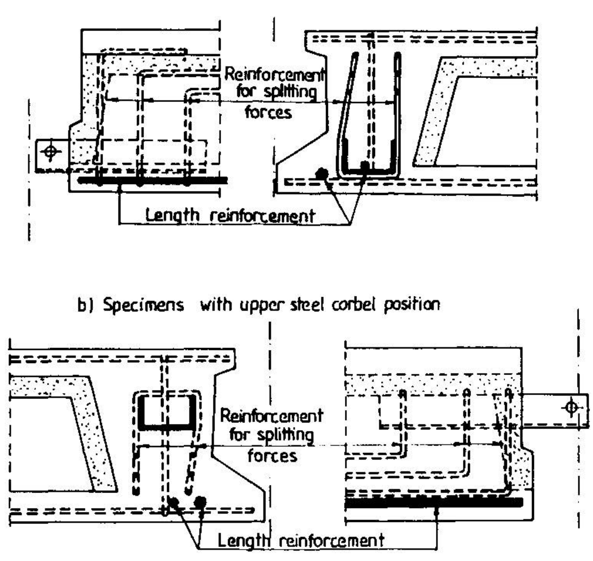


Fig.2 Reinforcement at the support for the specimens

The paper reviews some dimensioning methods which can be used at the support, considering concrete tensile strength 1,2 .

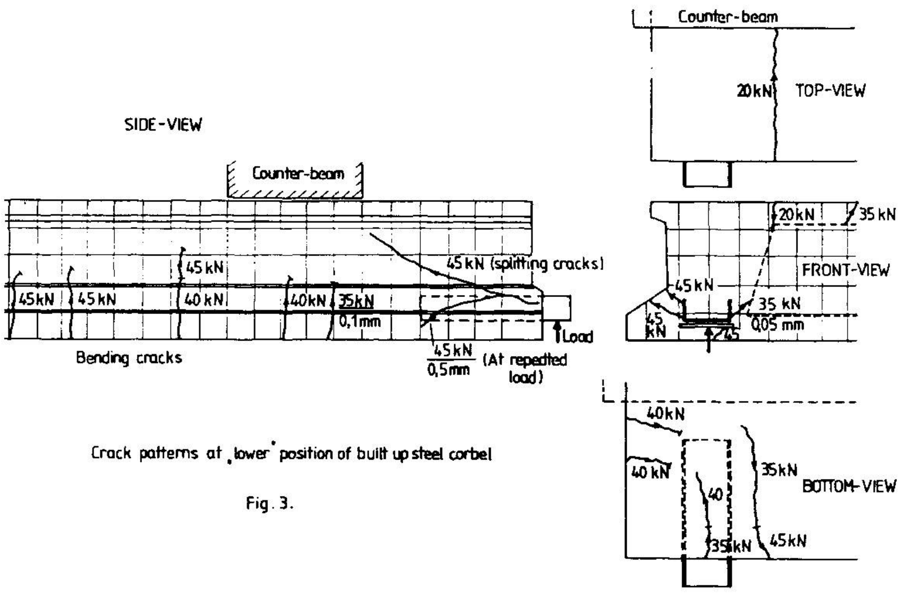
2. RESULTS FROM THE EXPERIMENTAL WORK 7

The reinforcement of specimens for the test is shown in Fig.2. During the step-by-step loading we measured the concrete surface strains and crack width. The typical crack patterns are shown in Fig.3 and 4.

With the steel corbel in the lower position it was found that the concrete surface around the corbel was crack free until 75% of the ultimate load. The cracks started from the inside-end of steel corbel. These craks can be regarded as splitting craks. Generally at the same load level bending cracks can also be found.

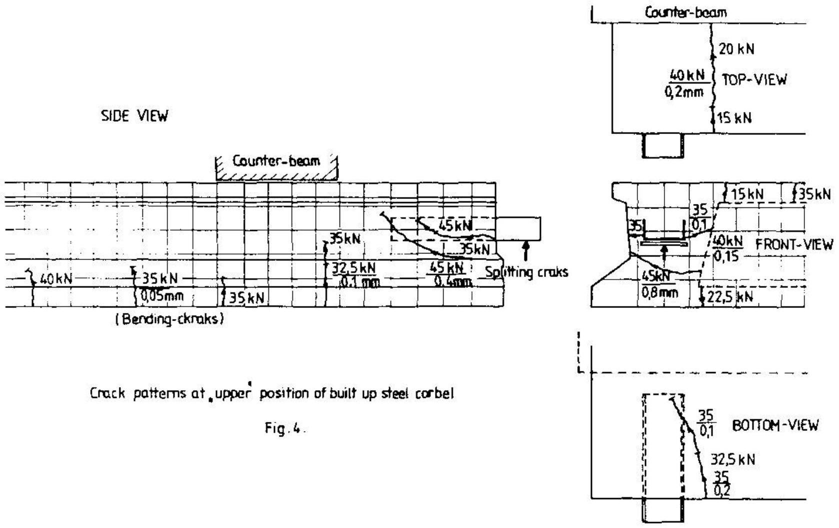
In the specimens where the steel corbel was in upper position we found crack free state until 60% of the ultimate load. The cracks started from the butt-surface, from the corner of steel corbel ascend.

In both cases the failure was caused by the yielding of vertical reinforcement.



Crack patterns at „lower" position of built up steel corbel

Fig. 3.



Crack patterns at „upper" position of built up steel corbel

Fig. 4.

3. POINT OF VIEWS OF DIMENSIONING

Besides providing ultimate limit state and serviceability limit state requirements during the dimensioning we have to take into account the following:

The steeel corbel outstanding from the concrete should be stiff in order to have a very small deflection. The sufficient built up length l_1, l_2 Fig.1 of steel corbel has to be provided.

A possible failure can cause a large economic damage and has a significant danger for the human life, therefore at the dimensioning we cannot take directly into account the tensile strength of concrete, because of brittleness 1,2 . Splitting forces arising around the steel corbel can be counterbalanced with vertically placed reinforcement Fig.2, where we can use one admissible value of tensile strength for concrete at the anchorages.

At the detailing we have to be ensure the connection between the steel corbel and the longitudinal reinforcement of the element, and to enlarge the redistribution zone by use of vertical reinforcement 2 . For the calculation of forces around the steel corbel we can use different types of models.

4. MODELS FOR CALCULATION

In this chapter we suggest some calculation models. We assume according Sant-Venant principle that part of the whole element near the support can be regarded like an independent structure.

4.1 Crack free state

Based on the experimental results 7 we assumed three typical, crack patterns Fig.5. where cracks are concentrated in one place. Along the fully developed cracks the tension stress distribution was taken from fracture mechanics approaches. The failure occurs if tensile stresses in concrete arrive the tensile strength f_t. The calculated tensile force is $F_{cr} = b \cdot \sum A_\sigma$. Reinforcement calculated from the vertical component helps to avoid brittle fracture. If the steel stress is reduced appropriately (exp. $\sigma_s = 0{,}4 \cdot f_{sy}$) the crack width can be controlled. By distributing reinforcement according to the tensile stresses, we can fulfilled the requirements (s.Ch.3.).

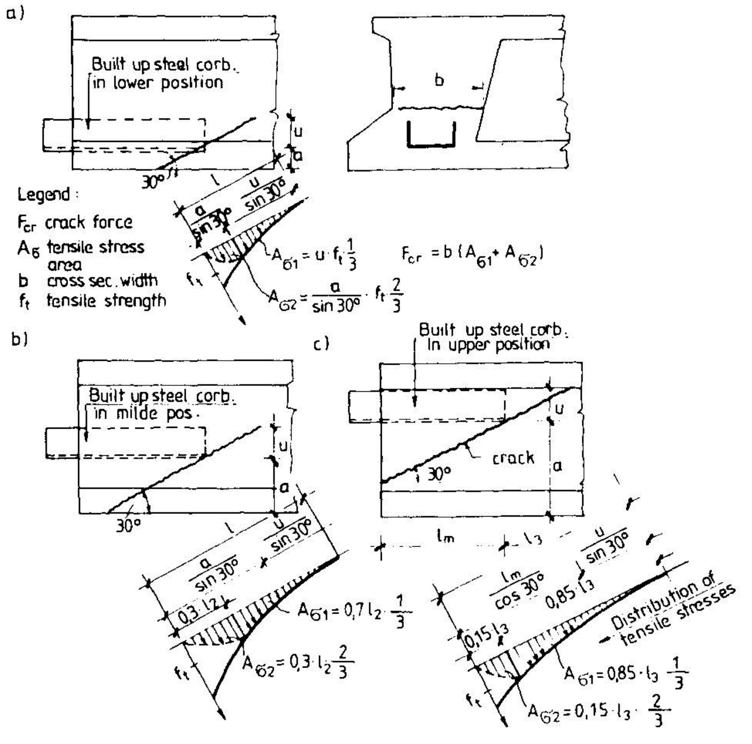
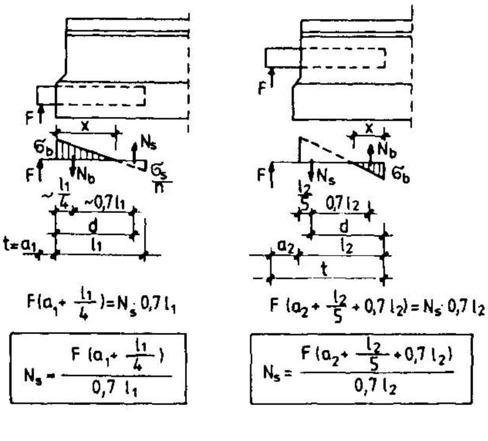


Fig.5. Calculation models in crack free state



Simplified calculation of the tensile forces

Fig.6

4.2 Cracked state

In the cracked state the equilibrium is arrived through reinforcement. A simplified calculation model is shown in Fig.6 . To use the moment equilibrium we have to choose some geometrical dates in the right way, or to make the traditional calculation. To fulfill the serviceability limit state requirements controll of the crack width, through the stresses in the tensioned members N_s has to be carried out.

4.3 Strut-and-tie models

To have clear "detailing" rules we need a more accurate model like strut-and-tie 5 . Depending on the position of the steel corbel we can develop three typical strut-and-tie models Fig.7 which follow the force paths indicated by the theory of elasticity. Controll calculation showed that strut-and-tie elements can be built up from concrete combining them with elements from the steel corbel, instead of using the steel corbel as a stiff body in this system. The results of an elastic calculation are given in Fig.7. The bearing capacity of concrete compression struts are shownd in 3. Tie forces are counterbalanced with reinforcement Fig.2.

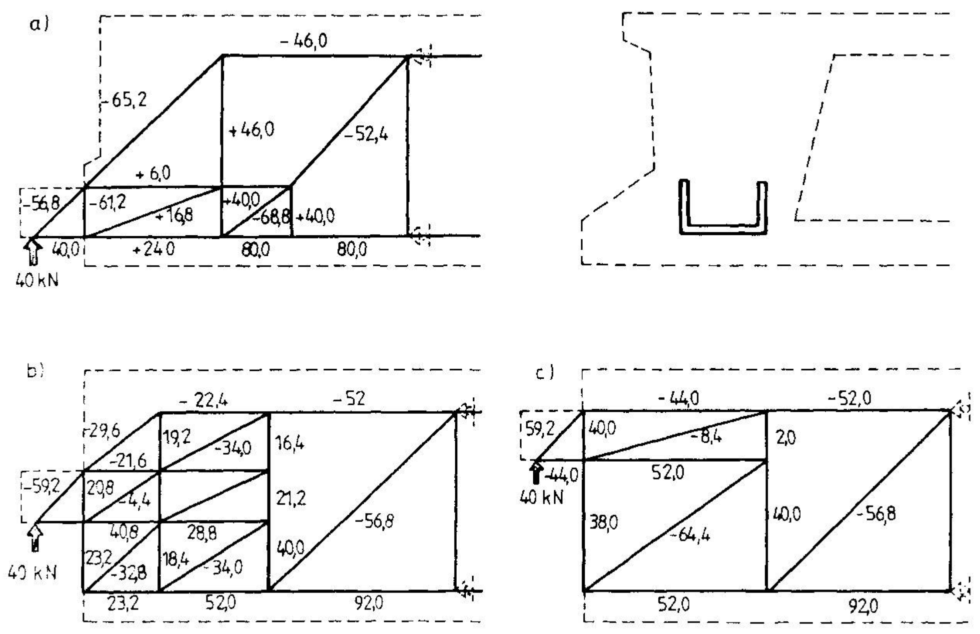
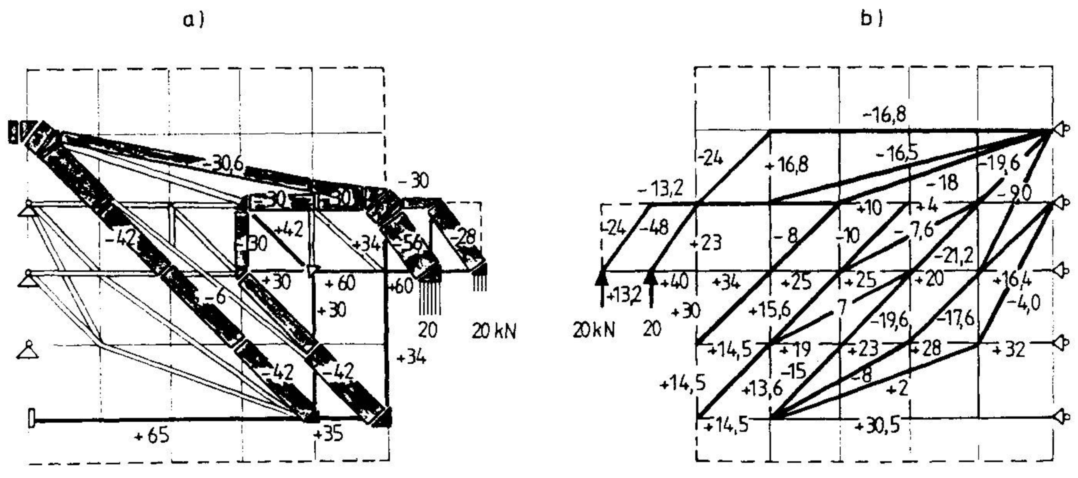


Fig.7 Strut-and-tie forces calculated on truss-construction



Calculation with stress fields

Fig.8

Calculation on detailed truss

If we chose a more detailed strut-and-tie model Fig.8b we get a finer force-distribution. Comparing these results with a more sophisticated calculation Fig.8a (statically admissible stress-field 6), we can find some differences in the forces. The clearly determined tensile forces followed with a proper detailed reinforcement, using one admissible tensile strength at the anchorages, secure us a good result.

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