BEHAVIOUR OF SHALLOW
REINFORCED CONCRETE BEAMS

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A Thesis
Submitted In Partial Fulfillment of
Requirements for the Degree
of
Master of Science in Civil Engineering
at
Yarmouk University, Irbid, Jordan

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Chapter 1

Introduction

1.1 General

A precise understanding of the behavior and response of shallow reinforced concrete beams is necessary, in order to be able to design the proper sections for the shallow flexural elements, that could serve their intended purpose, in terms of safety and serviceability requirements. Actually focusing this study upon shallow reinforced concrete beams is attributed to the dominant use of ribbed slabs with concealed shallow beams in building construction in Jordan.

The behaviors and responses that were detected and studied are the response of concrete cylinders under compression, the moment-curvature relations, the load-deflection relations and cracking of shallow reinforced flexural members.

Understanding these behaviors and responses serves to render the designed shallow reinforced flexural elements safe, able to resist all loads and forces, and serviceable.

The above mentioned behaviors and responses are affected by many variables.
Concrete used consisted of pozzolanic portland cement, Suweilih sand, medium and coarse crushed limestone aggregates.

Pozzolanity is still imperfectly understood, thus it is advisable to test any untried pozzolanic material in combination with the cement and the aggregate which are to be used in actual construction (17).

A study performed by Royal Scientific Society (R.S.S.) in February 1979, revealed that a great portion of aggregate produced in 261 stone quarries were of poor quality (22). Another study carried out by R.S.S. in June 1982 indicated that 18 millions of cubic meters of aggregate were produced annually, and tests performed to aggregates produced in 256 stone quarries indicated that still aggregate used was of poor quality (23).

1.2 Purpose and Scope

The purpose of this study was to investigate the behavior and response of shallow reinforced concrete beams, using local materials that are currently used in construction projects in Jordan.

The study was divided into four major parts. In the first part an investigation was carried out concerning the behavior and response of concrete compression members when subjected to uniaxial loading. Concrete cylinders 6 x 12 in were tested, the obtained stress-strain diagrams were

(2)
analysed, the average chord modulus of elasticity according to ASTM C469 was found to be 28452 N/mm$^2$. The strain at ultimate stress was 0.0021 mm/mm.

Only the ascending part of stress strain diagram was obtained since testing machine used, apply increasing load rather than increasing deformations, thus sudden failure of concrete cylinders occurred after the ultimate load is reached.

In the second part, the moment curvature relations for shallow reinforced flexural members were investigated. Six under reinforced concrete beams were subjected to loading, strain measurements were recorded and curvatures were computed for each loading increment. The experimental results were compared with computed moment curvature relations using the trilinear $M - \theta$ relation approach presented by Rao and Subrahmanyan (20). This method takes into account the rigidity contribution by the concrete in the tensile zone. The term trilinear denotes idealization of the moment curvature relation by three straight lines. Based on trilinear $M - \theta$ relation method, the moment curvature relation was investigated through three stages. In stage I, prior to cracking, the moment curvature relation was computed using the properties of the uncracked transformed section and based on elastic theory. Stage II takes place after cracking, the moment curvature relation was calculated using the properties of
cracked transformed section. In this stage, the contribution of tensile concrete between cracks was taken into account, applying an approach (24) that assumes the relation between steel stress in a cracked section and average steel strain. This stage is terminated when stress in steel reinforcement in tension zone reaches steel yielding strength.

Stage III is preceded by yielding of tensile reinforcement, the ultimate strength analysis adopted by ACI code 318-83 was followed to compute the M - $\phi$ relation.

In the third part, the experimental load deflection relations obtained by measuring the net deflections at mid-span of test beams, corresponding to different load stages, were compared to computed load deflection relations based on the method developed by Branson and adopted by ACI code. This method gives the transition of flexural rigidities.

In the fourth part, an investigation about flexural crack mechanism was conducted. During the test program the cracks were detected at the level of steel reinforcement using a magnifying lens accompanied by a scale. The crack widths corresponding to different load stages were recorded. Experimental results were compared with computed crack widths based on gergely-lutz equation which predicts the most probable maximum crack width at the level of steel reinforcement.
Finally results obtained experimentally and theoretically were analysed, discussed, compared and conclusions were presented.