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STRUCTURAL BEHAVIOUR OF PRECAST PROFILED CONCRETE PANELS RESTING AS FLOOR SLABS IN RESIDENTIAL STRUCTURES

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Abstract :

In this research study, the assessment of structural behaviour of precast profiled concrete panels was studied when used as floor slabs in residential buildings by testing of full scale models in laboratory. Trial mixes of locally available materials were used and cylindrical concrete specimens of concrete mixture were sampled and tested in accordance with the ASTM standards. Geometrical shape of the profiled panels was worked out in order to achieve optimum reduction in self-weight by eliminating the unnecessary portions of concrete under tensile stresses. In order to achieve an optimum concrete mix design, the actual results were cross-checked with the theoretically calculated compressive strength for the proposed panels. Two full scale specimens of the precast profiled concrete panels were constructed of the optimum concrete mix and reinforcement and finally, tested for third point loading. Precast profiled concrete panels showed excellent performance during testing and reflected failure in flexure. In addition, a reduction in self-weight of about 65% was noticed compared to solid slab made of the same concrete. Therefore, precast profiled concrete panels are recommended as structural supporting members whenever less weight and time for construction is an important objective to be achieved.

***Index Terms* - concrete panels, residential buildings, full scale models**

1. INTRODUCTION

Precast concrete is a construction product produced by casting concrete in a reusable "mould" or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place. In contrast, standard concrete is poured into site-specific forms and cured on site. [1] By producing precast concrete in a controlled environment (typically referred to as a precast plant), the precast concrete is properly cured and closely monitored by plant employees. Using a precast concrete system offers many potential advantages over onsite casting. Precast concrete production is performed on ground level, which helps with safety throughout a project. There is greater control over material quality and workmanship in a precast plant compared to a construction site. The forms used in a precast plant can be reused hundreds to thousands of times before they have to be replaced, often making it cheaper than onsite casting when looking at the cost per unit of formwork. [2]Like the name implies, a precast double tee resembles two side-by-side capital letter Ts. The two vertical leg sections are called webs or stems and the horizontal section is known as the deck or flange. The design of a precast double tee allows the deck to act integrally with the superstructure, as precast double tees have a monolithic deck and stem design. [3]Precast Profiled Concrete Panels products, as shown in Figure 1, are one of the most advanced building materials used in the construction industry today as they offer in a single building element, an economical method of providing structural requirements, and attractive architectural treatment. Therefore, the aim of this research was to further explore and understand the behaviour of Precast Profiled Concrete Panels.

Figure 1: Use of Profiled Concrete Panels as roof slab

1.2 OBJECTIVES:

Following are the objectives of the proposed work:

- In order to find out the optimum mix design, samples of trial mixes were prepared and tested in the laboratory based on the theoretically worked out mix design considering the projected compressive strength of concrete for design and construction of Precast Profiled Concrete Panels.
- Strategy adopted to cast prototypes
- Evaluation of output results after testing for strength and serviceability

2 RESEARCH METHODOLOGY

This research was based on normal weight Precast Profiled Concrete Panels for use as Floor Slabs in residential buildings and included studying the behaviour of normal-weight precast profiled concrete panels reinforced with bars in conformance with ASTM A615 Grade 40 [4].

2.1 Experimental strategy:

2.1.1Trial mix:

Trial mix of concrete was used to cross-check the targeted theoretically worked out optimum mix. The ratio was adjusted to the nearest rounded ratio of 1:3:4 based on the nearest theoretically worked out rounded ratios by volume of the designed concrete mix. Cylindrical concrete specimens, as shown in Figure 2, were made, cured as per ASTM C192 [5] and tested in the laboratory as per ASTM C39 [6].

2.1.2Geometrical shape:

A Precast Profiled Concrete Panels is a modified geometrically shaped slab similar to a normal slab panel in function, but, with less self-weight. For the presumed clear span of 10’-0”, in the design process different shapes of panels were being considered and evaluated to work-out the optimum shape of section considering self-weight, strength and serviceability requirements as per ACI 318-95 [7]. The following cross-section of the panel, as shown in Figures 3 and 4, was figured-out as the most appropriate section.

Figure 2: Concrete specimens testing in lab

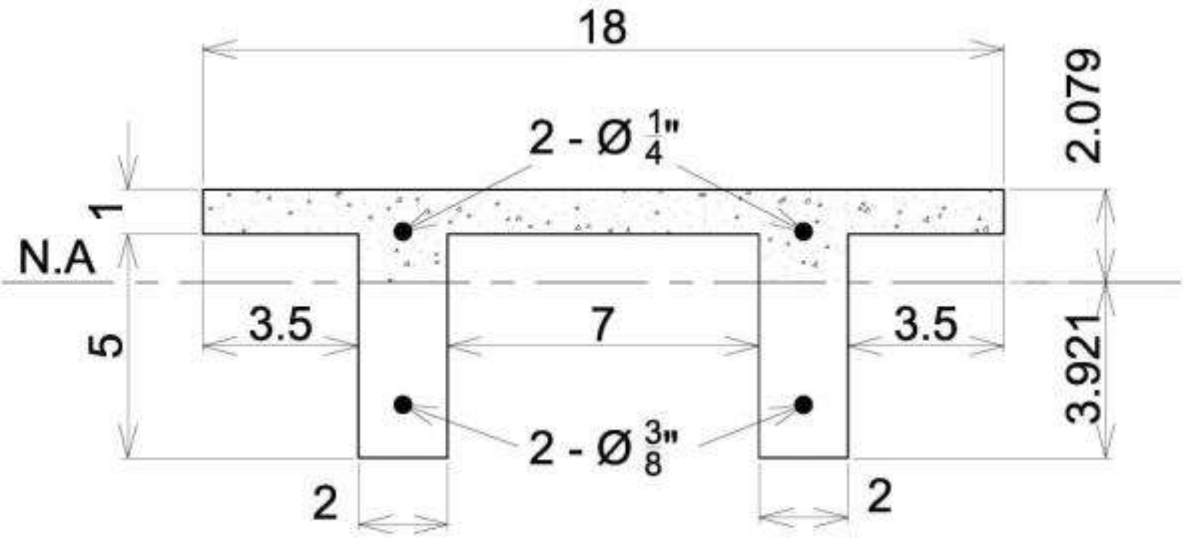

Figure 3: Cross-section of profiled concrete panel (Dimensions are in inches)

Figure 4: Concrete pouring in formwork for panel

2.1.3 Testing in laboratory:

Two full scale prototypes were successfully tested for third point loading in the lab, as shown in Figures 5 and 6, and results were recorded with data-logger for further evaluation.

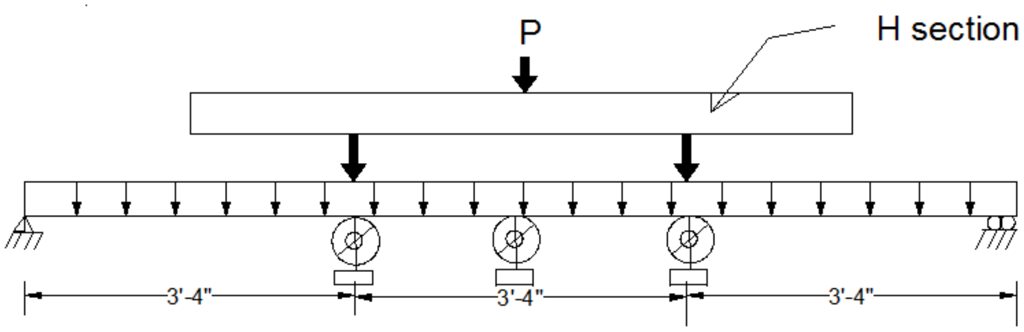

Figure 5: Loading setup for recording of deformation

Figure 6: Loading setup for recording of deformation

Figure 7: Ductile behaviour of panels when loaded

3.Stress-strain analysis of profiled precast panels:

Generally the behaviour of concrete is brittle and the aim in the design of reinforced concrete members is always to have a ductile failure with warning for safety of the occupants. Quantitative measurement of stress-strain analysis is very difficult to be measured properly for precast profiled concrete panels due to variable parameters like materials, atmospheric factors, loading pattern and so on.

Stress-strain graphs of the tested profiled precast concrete panels are presented in Figures 8 and 9.
The red-line represents cracked section behaviour up to peak.

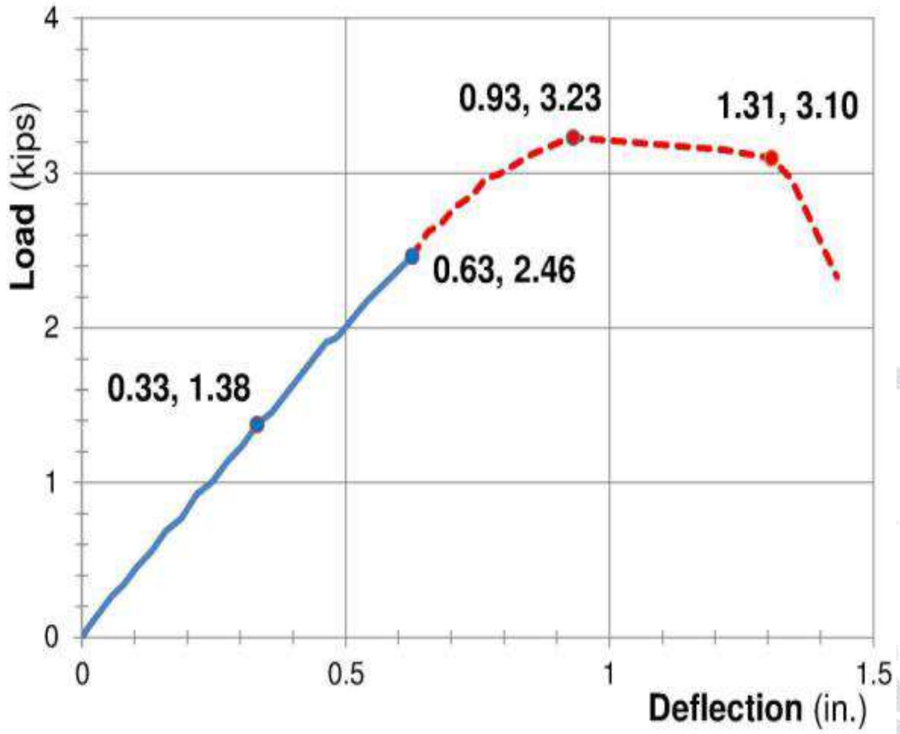

Figure 8: Deformation-Load relationship for first panel tested

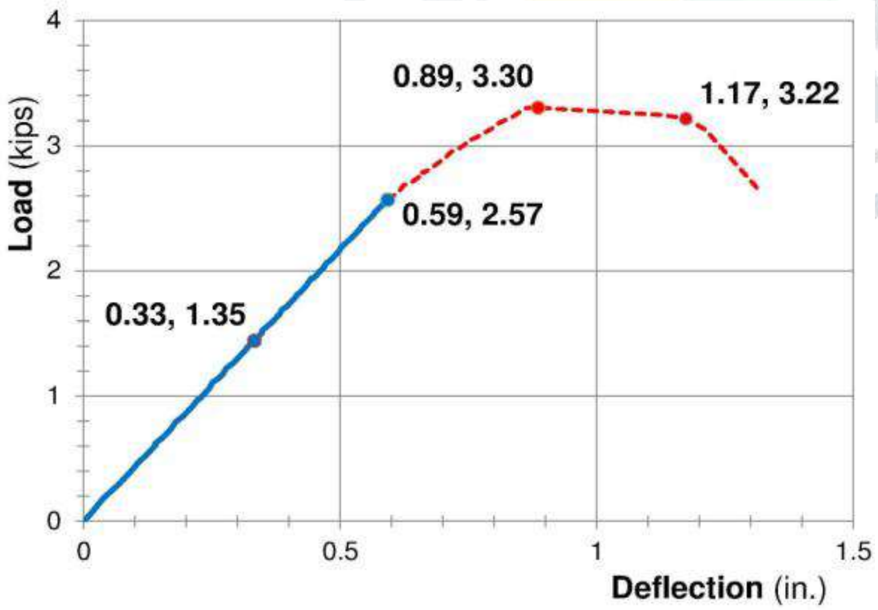

Figure 9: Deformation-Load relationship for second panel tested

3.1.1 Serviceability analysis of Profiled Panels:

Maximum deflection limits as per Building Code of Pakistan (BCP SP-2007) [8] and UBC 1997 [9] are:

For Dead and Live Load combination:

Δmax (DL+LL) = L/240 = 10*12/240 = **0.5**”

For Live load only:

Δmax (LL) = L/360 = 10*12/360 = **0.33"**

Figure 10: Cracks pattern under loading

From Figures 8 and 9, for the above mentioned theoretical maximum deflection of **0.33 inches** due to additional live load, the corresponding values of load is **1.38 kips** and **1.35 kips** for the two panels respectively. Which can be further worked out to be equivalent to **123 psf** and **120 psf** for the two panels respectively. Which means that even such profiled slab panels can also be effective in areas where possibility of more load and less duration of construction are required.

3.1.2Comparison of properties of profiled slab panels and conventional slab:

Table 2 reflects properties comparison of precast profiled concrete panel and conventional slab of 10 feet clear span.

Comparison of properties shown in Table 2 for profiled precast concrete panels and normal solid slab shows about **65%** reduced weight for precast panels. This reduced weight will ultimately result in further economy of the whole structure due to reduced size of supporting members and foundations particularly in multi-storey buildings.

Properties	Precast Profiled Concrete Panel	Conventional slab
Sizes (Equivalent thickness by volume)	2.11 in *	6 in
Self-weight	26.39 psf	75 psf
Depth of compression block	0.29 in	0.29 in
Ultimate Moment capacity of the section for provided reinforcement.	38.45 kip-in	38.45 kip-in
Self-weight ratio	35.2 %	100 %
Availability for use	Immediate	After 3 to 4 weeks

3.1.3Research outcome and discussions:

Concrete specimens

The following results, as documented in Table 1, were recorded for the concrete specimens as tested:

Mix Ratio	Slump (Inches)	7 days strength (psi)	28 days strength (psi)	Failure patterns	Mix Ratio
1:3:4	≈ 3"	1580	2170	Columnar	1:3:4
1:3:4	≈ 3"	1690	2230	Columnar	1:3:4

3.1.4Concrete Panels behaviour:

After the application of load with gradual increment, the behaviour of the profiled precast concrete panels were ductile until failure occurred as shown in Figure 7. Only flexural cracks within the middle third portion were observed propagated from bottom and leaded towards top flange with the continual increment of load as shown in Figure 10.

4.Research Recommendations:

Profiled Slab Panels can be used for office , industrial educational and like buildings for which the service load is more than residential.

The Profiled Slab Panels has reduced weight which is easier in lifting than solid precast slab panels.

Profiled slab panels are economical for almost all the buildings/structures but more economy can be achieved for high rise buildings as it has considerable effect on the overall cost of the project by reducing the sizes of supporting sections.

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