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STEEL GRID RESEARCH

INTRODUCTION

Due to significant weight savings, Steel Grid Floorings, both Open and Concrete Filled, are integral components of many structures, both fixed and moveable.

Open Steel Grid Floorings have been used with much success in many areas. For example:

1. Moveable Bridges - where the 'ultralight' dead load (15-25#/SF) enables significant reduction in the machinery and counterweights needed to move the bridge.

2. Temporary Bridges - where lightweight, modular bridge deck panels facilitate rapid field assembly. Several state DOT's have instituted stocking programs, which include the use of Open Grid Decking panels, to handle a variety of emergency situations.

3. Rehabilitation - to quickly and economically restore older bridges to usefulness by drastically reducing dead load through the use of an Open Steel Grid deck.

Filled Composite Grids (or Concrete Filled Steel Grids) fill important market niches in the following ways:

1. To reduce deck weight on a long span steel bridge, thereby reducing structural members (truss members, for example) resulting in overall bridge economy.

2. For rehabilitation, to upgrade live load capacity through dead load reduction, and to facilitate staged construction in heavily congested metropolitan areas through modular Grid Deck design.

BACKGROUND

Despite a long product history and wide useage of both types of decks, basic properties and behavior is not well documented through research and, as a result, design inefficiencies exist. For example, current AASHTO formulas for Open Grid are based solely on research performed in the 1940's, and through field observation. Recent information on Open Grid fatigue characteristics, developed through a research program conducted at West Virginia University, has not yet been adopted.

Design inefficiencies are even more pronounced for Concrete Filled Grids. AASHTO specifications require that Concrete Filled Grids be designed the same way as reinforced concrete. Live load distribution, both within a Filled Grid and to the stringers is conservative; for example, live load distribution of a concrete deck to the stringers is S/5.5, whereas it is S/5 for a Filled Grid. Fatigue in a Filled Grid has not been addressed by AASHTO, and therefore some designers apply fatigue provisions more appropriate to Open Grids. (It should be noted that AASHTO does not address Open Grid fatigue directly). The long performance history of Filled Grids has shown that these assumptions are extremely conservative. Other important design issues, such as calculation of effective width of deck when designed compositely with support members, have never been adequately addressed.

Several research programs have been initiated to address some of these design difficulties. One such program is underway at West Virginia University's Constructed Facilities Center at Morgantown, sponsored jointly by the West Virginia DOH, the FHWA and the Bridge Grid Flooring Manufacturers Association. In addition, a comprehensive researh program, sponsored by IKG/Greulich, a steel grid manufacturer, and Penna's Ben Franklin Partnership, is being conducted at the University of Pittsburgh. This research program at Pitt is the primary subject of this discussion.

RESEARCH METHODS

The research at Pitt empasizes the establishment of basic, fundamental properties of grids. The initial task was the determination of section properties of several Open and Concrete Filled Grids. Physical testing, along with theoretical methods, are used to compute, and develop methods to compute, section properties of Steel Grids.

Finite Element modeling of grids is the preferred method in order to study strength and live load distribution, rather than subjecting any new product designs to a complete battery of tests. Modeling grids with finite element is nearly impossible, given that a grid consists of many small elements, and considering existing hardware and software limitations. However, if equivalent plate properties of grids are known, one could make a finite element model of a grid panel using plate elements.

An experimental method which is used for determination of the orthotropic elastic constants of plate was adapted for steel grid. To compute the elastic constants of plate required three tests; test set-up for each is shown in Figures 1 and 2.

From deflections measured from the test set-up shown in Figure 1 one can compute S_{11} and S_{22}, where $S_{11} = 1/E_{11}$ and $S_{22} = 1/E_{22}$. From the test set-up shown in Figure 2, S_{12} can be computed, where S_{66} = 1/G. From these, one can compute plate constants C_{11}, C_{22}, C_{12} and G. This informaion is sufficient to model *orthotropic* plate.

Finite element analysis, rather than experimental testing, was initially used for computation of these properties. A heavy duty (main grid I-beams spaced 3-3/4" apart) diagonal type Open Grid was the first grid design selected for study. Figures 3 and 4 show the finite element model which was used for the computation of plate constants. These models were supported and loaded for the three cases described. The computer program SUPERSAP was utilized for analysis of these three models. Deflections were computed, and from these values, plate coefficients are computed.

This information was then used for modeling of a simple span 6' x 10' heavy duty diagonal type Open Grid. Material for the model was A588 and the load applied was a 10 kip concentrated load. Forces and maximum stresses in the steel were computed.

For verification of the analysis results, a full scale test of the panel was performed. Following is a summary, and comparison of the physical test with the finite element analysis result. Note: Displacement and stresses shown are for H-20 truck without impact. These values are computed from a 10 kip load.

	Physical Test	Finite Element
Stress at Top	20.752 ksi	22.646 ksi
Stress at Bottom	19.744 ksi	18.238 ksi
Deflection	0.377 inches	0.357 inches

Stresses were computed for H-20 load plus impact, and were 30 ksi; testing verified these stresses. According to finite element and test results, this product can carry an H-20 load on a span of approximately 9'. The allowable span according to current AASHTO, and as shown in the IKG/Greulich catalog, is 6'. One of the main reasons for the significant difference is that AASHTO ignores the torsional properties of the heavy duty diagonal grid. It should also be noted that torsional properties of Concrete Filled Grids are ignored by current AASHTO specifications.

Tests at the *University of* Pittsburgh involve ten (10) different grid designs. Section properties of these ten panels will be computed for both Open and Concrete Filled Grids by physical testing and finite element analysis. Although the comparison of tests already completed and finite element are in good agreement (greater than 91%), additional comparisons are required to adopt these theoretical methods for the computation of section properties of Open and Concrete Filled Grids.

The testing at Pitt will investigate other factors as well, including:

1. effect of cross bar on live load distribution and sectio properties
2. fatigue
3. live load distribution to stringers
4. effective width of slab for composite section properties