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Technical Division Benchmark Structure for Dynamic Substructuring

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1 Abstract

Experimental-analytical substructuring has been a popular field of research for several years and has seen many great advances for both Frequency Based Substructuring (FBS) and Component Mode Synthesis (CMS) techniques. To examine these technical advances, a new benchmark structure has been designed through the SEM Dynamic Substructuring technical division to act as a benchmark study for anyone researching in the field. This benchmark challenge includes both experimental subcomponents and a finite element model. Together, these subcomponent representations are used to predict the system response of the benchmark structure. We often know the truth target when completing substructuring research; however, truth in system modeling is a difficult concept to create. The structures dynamic behavior may change drastically every time it is assembled, tested, or manufactured. IMAC XXXVII attendees are encouraged to contact the authors to learn more and participate in this in this challenge. The results from the assembled truth measurement will be presented at IMAC in 2021.

2 Research Strategy

Recently, there has been copious amounts of research surrounding experimental-analytical substructuring within the SEM community. In 2011, the experimental substructures focus group selected a testbed structure, the Ampair 600 Wind Turbine. The origin of this test bed is discussed in detail in [1]. Many research institutions have studied this original benchmark structure, Sandia National Labs and University of Wisconsin studied the structure in [2, 3] with applications of the component mode synthesis technique the Transmission Simulator method [4]. Rahimi [5] and Brunetti [6] studied this structure using Frequency Based Substructuring methods. The testbed became widely used by several other universities across the globe including University of Massachusetts Lowell [7], University of Stuttgart [8], Linnaeus University [9], and many more collaborators. During these studies several new methods and technologies were developed, but the Ampair 600 Wind Turbine turned out to be quite a challenging structure.

First, as discussed by Harvie in [7], the blades of the wind turbine appeared to have variance in interface tolerances which could have large impacts on the testbed research as depending on what blades a researcher obtained they may find very differently assembled results. Second, as has been the study of much research, the bolted joints in the Ampair Wind Turbine create a significant source of nonlinearity which can have adverse effects when exploring the world of experimental analytical substructuring. Despite the difficulties that came from the AmpAir 600 test assembly, the structure led to over a decade of collaboration and progress in the fields of dynamic testing, experimental substructuring, and system modeling.

At IMAC XXXVI the focus group on Dynamic Substructuring officially transitioned into a Technical Division of SEM titled Dynamic Substructures. During this inaugural meeting, the Technical Division discussed the creation of a new benchmark structure to kick-off a new era of research in experimental analytical substructuring. It was determined that a new benchmark structure would be an appropriate test of the current capabilities of the Dynamic Substructures Technical Division and would foster future collaboration.

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3 Design and Considerations

A collaborative team across many research institutions was formed through the SEM Dynamic Substructuring Technical Division. This team developed a list of desirable qualities for the new benchmark system. Qualities included:

- Minimization of nonlinearities due to interfaces
- Challenging interfaces or configurations for both CMS and FBS techniques
- Adaptable design for future studies (i.e. circular transfer paths, nonlinearity due to joints, multiple fields of application)
- Simpler than the AmpAir and easily manufacturable
- Designed with the intent of experimentation (i.e. mass loading, attachment points, coordinate systems aligned)

The team developed a unit-frame design shown in Figure 1. The unit frame design is adaptable to multiple fields of study such as automotive frames, aviation industry, and even civil dynamics. This frame is shown in further detail in Figure 2. It consists of four units and includes 10/32 tapped holes to attach subcomponents for testing. Additional holes are located on the side of the frame to attach impedance heads or force transducers.

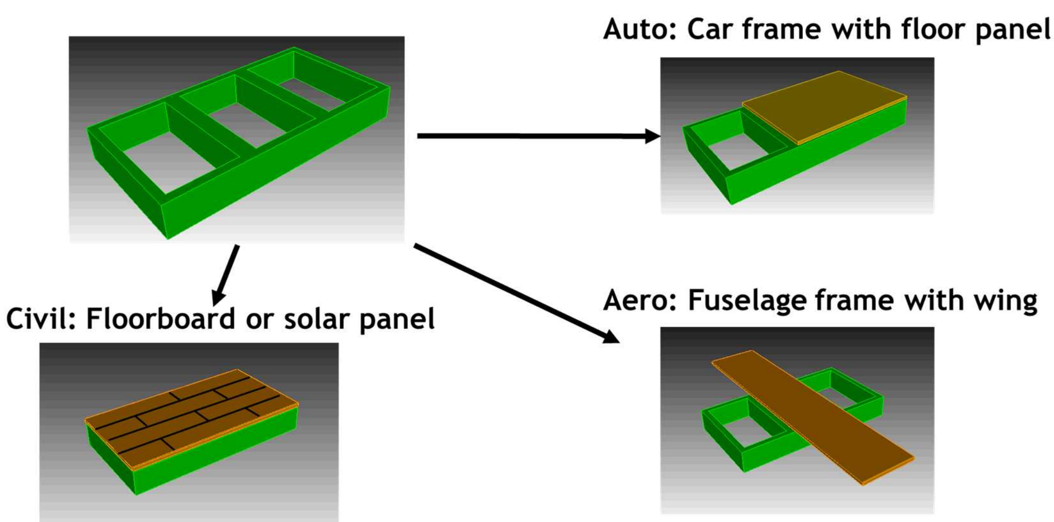

Figure 1. Unit Frame and Applications

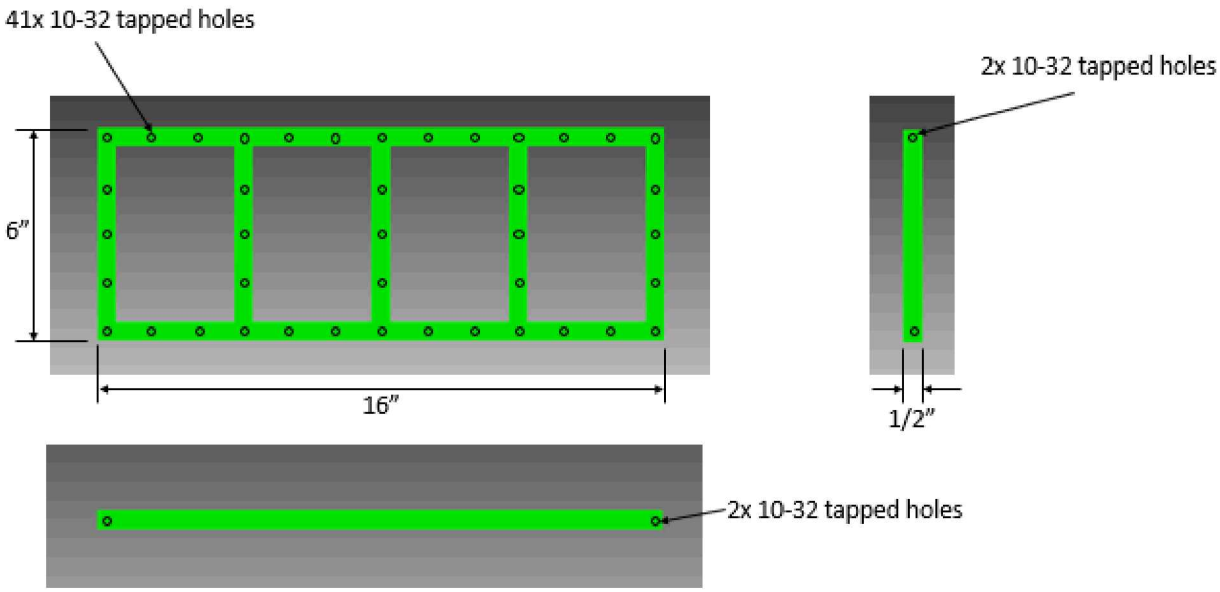

Figure 2. Frame and Design Details

A preliminary, finite element model-based, modal analysis has been completed on the frame design which will be presented at IMAC in 2020. Interested researchers should plan to attend this session and the Dynamic Substructuring Technical Division meeting to learn more about the frame, other component selection, and how to get involved and test this benchmark system.

4 Closing Remarks

The objective of this proposed work is to continue to foster collaborative and cutting-edge research in the field of experimental-analytical substructuring. The benchmark challenge will be useful in completing two main tasks. First, it will provide research institutions a useful means to test their substructuring capabilities. Second, it will allow a comparison of techniques and simple system for future collaborations for years to come.

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