Structural Engineering Guidance No. 15-01

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Distribution: Internal Bridge Structural Design Resources Only

SUBJECT: *MIDAS CIVIL* STRUCTURAL ENGINEERING SOFTWARE IMPLEMENTATION

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EPG Status: NA

Effective Date: Immediately

Expiration/Duration: Active Until Fully Implemented or Revised

Introduction and Background:

MIDAS CIVIL structural analysis and design software was procured for three reasons:

1. Replace SAP2000
2. Analyze and design substructures with drilled shafts using one software program
3. Allow for bridge modeling options

MIDAS CIVIL is produced by MIDAS Information Technology Co., Ltd. (MIDAS IT) with headquarters based in Korea. MIDASoft, Inc. is the US headquarters office in New York, New York. It is advanced structural engineering application software that competes in the engineering software marketplace with other major commercial structural engineering software like LARSA, LUSAS, Bentley RM BRIDGE, and CSI BRIDGE (SAP 2000 enhanced for bridge modeling).

MIDAS CIVIL (MIDAS) is *“bridge centric”* meaning that its main focus is on bridge structural modeling, analysis and design unlike SAP2000 which is deficient in a couple of major areas of design like compliance checks with an appropriate design specification(s) and bridge live load generation. MIDAS incorporates several national and international design specifications one of which is AASHTO LRFD Bridge Design Specifications. Since purchasing MIDAS, MIDAS IT has included in its girder shapes library several of Missouri DOT PSI Standard Girder Shapes for bridge design. (*Note: SAP2000 is a powerful program in its own right and has been maintained for almost 15 years by the Department. It may have proficient users. Three licenses of SAP2000 remain of the six original licenses, two of which will be temporary licenses and one license of SAP2000 will be permanently retained for independent use and as it is interfaced with the in-house box culvert design program*.)

MIDAS can perform drilled shaft (and pile) modeling as part of a substructure unit. Drilled shaft foundations are part of our regular diet of foundations for substructures and the trend seems to be upward. It is not foreseen that this trend will slow down, so in order to keep up with demand and improve upon some of the headway made in drilled shaft design over the years, MIDAS is recommended to perform and combine the work of two programs (LPILE and RCPIER) currently used in tandem replacing how drilled shaft modeling is performed now. Doing so will likely lessen drilled shaft design time since multiple shafts per bent can be designed concurrently and may cut construction costs to a degree that shafts which can be modeled as part of a full (whole) bridge model may demonstrate a structural efficiency associated with a more likely representative model of anticipated full bridge response.

MIDAS includes many bridge modeling options: FEA, girder line analysis and design\*, superstructure 3D analysis, substructure analysis, foundation analysis, pile analysis, integral abutment analysis, 3D full bridge analysis, thermal analysis, seismic analysis. These options will allow closer estimation and examination of predicted bridge response for new structures and closer evaluation of actual bridge response for existing structures like forensic engineering. More than likely since all of these options are integrated into one program, to utilize them will be enticing and seem natural; and the output between using different options will be quickly changeable and reviewable which may lead to a false sense of confidence and command of the software. That is why overenthusiasm should be tempered by prudence and a contemplative respect that comes from studying a program and its nuances so that strong modeling aptitude develops over time; which is why it is believed that MIDAS, state of the art in structural computing, will satisfy future professional growth demands because of the many options; by participating in its maintenance through utilizing its customer service, this is another way of studying and advancing learning and it will allow MoDOT to influence future enhancement features.

*\* MIDAS can perform iterative steel girder design. However, it cannot perform iterative prestressed concrete*

 *girder design yet. This enhancement is scheduled to be available by the end of the year.*

Recommended Implementation Plan with Guidance:

The recommended implementation plan gives a framework for achieving Bridge Division engineering design goals and training goals. It is being distributed to users to move us forward in using the program.

The recommended implementation plan is 3-Level, simple and based on achieving a desired development of users’ skills and modeling aptitude. Successful implementation is in major part to create the desire to use, re-use, build user-retention and develop mentors which will lead to many users having developed the appropriate level of modeling skills to ensure a comfort and consistency of use, if it is to be precise in order to promote repeatability and reproducibility (both terms, as used here, refer to the user’s ability to repeat a previously used modeling concept and another user’s ability to reproduce an earlier user’s successful modeling concept run, respectively and in terms of program results).

THREE-LEVEL IMPLEMENTATION PLAN

MIDAS CIVIL can downloaded to your desktop upon request to John Gahagan of IS.

**LEVEL ONE (PRE-CLASS):** *On-Line**Tutorials and Examples, Simple Models, Members, FEA*

ACTION: Explore on-line tutorials and examples. Incorporate into work for simple member or frame models or FEA modeling. Examples could be a pile bent cap, manhole cover, bridge wing, guardrail post and anchor plate. Review midasuser.com for free training resources like tutorials and webinars. Use is encouraged and will enhance MIDAS IT training class to follow.

<http://en.midasuser.com/training/main.asp>

<http://en.midasuser.com/training/webinars_list.asp>

ANTICIPATED RESULTS:

1. Build familiarity; learn the ribbons
2. Preparedness for a MIDAS CIVIL instruction class on FEA modeling, girder modeling, and full bent and bridge modeling
3. Develop questions for training class

**LEVEL TWO (MATCHING):** *Complex Models and FEA*

ACTION: Incorporate in work for drilled shafts, piers, full bents with columns and drilled shafts, concrete beams, steel girder line, replacement bearing shelf, pile bent, single pile cap footing, bent on spreads (MIDAS CIVIL does not do spread footings)

ANTICIPATED RESULTS:

1. Increased ability; using learned skills from training class
2. Increased use and retention
3. Incorporate into team design
4. Mentoring, teaching
5. Develop champions, mentors
6. Modeling drilled shafts using one modeling program
7. Terminate 2 SAP2000 licenses except 1 license

**LEVEL THREE (TRANSITIONING):** *Advanced Models, Full Bridge Modeling*

ACTION: Full bridge modeling, integral abutment modeling, full bent effects, longitudinal load analysis (thermal, wind, braking), culvert analysis, seismic modeling; Further guidance from Development Section

Work closely with team documenting model assumptions, rigidities and constraints.

ANTICIPATED RESULTS:

1. Refined modeling
2. Predicting full structural response
3. Furthering structural engineering software modeling
4. Construction cost reductions via more precise design
5. Evaluating actual full structural response

A foreseeable challenge to a successful implementation of MIDAS is overindulgence, or rapid interest in all the bells and whistles of the program; don’t or take on too much at once and risk faulty work and a resistance in going forward; to resist the temptation to learn it all at once or to learn it as fast as you can may be how mastery of this program works; too quickly learned and results can be compromised leading to misperception about program complexity which could be an obstacle in going forward. Therefore, skill building, developing modeling aptitude and training, while encouraged through a strategic implementation plan, personal or as given above, are in the long run ultimately left to the designer and our system of checking each other’s work as appropriate for which personal, or team, pace and talent can be harmonized. Managers are encouraged to encourage the time to instruct oneself.

 *\* Loads and reactions for example are typically transferred between different programs (can introduce errors)*

**DISCUSSION: *WORKING at LEVEL TWO (MATCHING)***

**Compare Results: Verification and Validation**

**Examples**

**Verification and Validation**

Comparing results using hand calculations or different software programs is important for a successful implementation.

To borrow some technical processes from product, service and system development that may be appropriately applied to this implementation, “Verification and Validation (V&V)” are processes that when used in the context of this implementation refer simply to verifying the output of MIDAS and on a larger stage validating the purpose and usefulness of MIDAS. In other words, verification may be thought of as answering the query, “Is the software built right?” and validation may be thought as answering the query, “Is it the right software?” Ok, deep enough, but it does apply to this implementation, if MIDAS is the right software, how and to what extent should MIDAS be utilized?

Verification is a check that MIDAS is performing the analysis correctly (and bridge code checks if applicable). It is performed by reviewing the output using statics methods, simplifying assumptions to get ballpark results, or using other programs. It should be performed within the normal format and boundaries of our bridge design/check system. Verification should not be presumed to be satisfied automatically. Though MIDAS is a popular and mature commercial software program (developed in 1989) with a great customer service reputation, good engineering practice dictates that software performance should be verified (do not be fooled by all the bells and whistles). Utilizing the customer service support and reporting any impreciseness or bridge code malfunctions using this program can be another way of pro-actively dealing with verifying performance. It is left to the SPMs and design teams to coordinate these responsibilities between individuals.

Validation is a check on whether this software will meet our needs at this level. The proposed modeling in LEVEL TWO is really just matching where our modeling skills are at as a Division right now; so it makes sense that we would want to validate MIDAS to the level that would be expected and necessary of any software program and it is expected that it will. (Validation really takes on a much more significant role at the next level.)

Finally, rating software WILL be the final verification for any superstructure modeling runs without exception since it is used for reporting NBI data and must be used.

**Some Examples of Verification**

1. For performing drilled shaft design, design/check with LPILE and RCPIER results.
2. For steel girder designs, design/check tandem should include MIDAS plus MDX.
3. For PSI girder designs, MIDAS will only analyze input strand arrangements (losses may be different) and will not perform design iterations at this time (PSI Wizard is an expected release at end of year).
4. For substructure, design/check tandems should include MIDAS plus RCPIER.
5. For foundations, design/check tandems should include MIDAS plus LPILE.
6. For previous run SAP2000 models, run a similar MIDAS model for comparison.

*Note: MIDAS will not analyze spread footings or driven pile for axial load capacity.*

**DISCUSSION: *WORKING at LEVEL THREE (TRANSITIONING) and A LOOK AHEAD***

**Compare Results: Verification and Validation**

**MIDAS Guidance**

**Does MIDAS exceed the “design need”?**

**Rating**

**Viewpoints on Usage**

**Verification and Validation**

LEVEL THREE follows the same rationale as in the second level but goes further.

Full bridge modeling is new to MoDOT Bridge Division. We do not practice it, so we don’t know how to practice it, nor model it, nor check it. Fortunately, it’s in a field we all know and are familiar with which means it is just a matter of on-the-job professional studying. Verification and validation are a bit more challenging to check since full bridge modeling is new to MoDOT. For starters, it is important to contrast how bridge design is performed now and how MIDAS can perform bridge design when engaged at full capacity.

Analyses and designs are now performed utilizing several independent structural software programs, spreadsheets, Mathcad and hand calculations that require data turnaround\* and simplifying assumptions. While this type of independent modeling can still be performed in this fashion with MIDAS, one will eventually discover that that is undervaluing and underutilizing the capabilities of a comprehensive program which will likely spur headway into more advanced features of the program like full bridge modeling.

This makes answering the queries “Is the software built right?” and “Is it the right software?” more challenging.

Verification using conventional models will work to a degree; hand methods may actually be quicker when considering displacements and model constraints. But it goes further since loadings can be computer generated and especially live loadings. The program is well documented with a very thorough help guide.

Validation is equally challenging since MIDAS creates the opportunity for changing the MoDOT bridge design paradigm; it is difficult to determine if the software is the right software. Can full bridge modeling be implemented? Should it be implemented? Is MIDAS the right product for implementing this change? These are validation checkpoints.

LEVEL THREE is then a transition point when bridge modeling can become more radical, more refined, and more accurate, more challenging and when more modeling skill is necessary and when more guidance may be necessary to support and sustain direction. Had we this capability with SAP2000, we probably would be beyond this point already.

Will MIDAS exceed the “design need”? No. The need has always been there; we are just catching up with the programming available. Procuring MIDAS does satisfy two immediate “design needs”, i.e. to replace SAP2000 and to make drilled shaft analysis and design more straightforward and lean. However, its capabilities exceed our conventional structural modeling and simplified structural assumptions which will allow advanced modeling options and more precise structural analysis and evaluations in the future. Modeling options could include more refined methods which have been allowed by AASHTO LRFD for over twenty years.

Implementation is left to the design teams. When and how to implement may be answered by reviewing the follow viewpoints:

**Viewpoints on Using MIDAS at LEVEL THREE:**

**Full Bent to Full Bridge Modeling**

 *Fast Jobs*

 *Normal Jobs*

 *Simple Bridges*

 *Complex Bridges*

 *Complex Modeling*

*Substructure Modeling*

*Full Bent to Full Bridge*

 *Training Bridge Designers*

 *MIDAS Experiences at DOTs*

1. Reliable conventional design methods may be more effective for fast jobs; that is, there is efficiency and comfort in our current design routines. And for the long term this may be true also. Do not abandon them.
2. In order to learn MIDAS and integrate it into our design culture at a comprehensive LEVEL THREE, the recommendation is to start simple on normal jobs (“normal” is left to the teams to define). Encourage full structure modeling on simple structures to gain experience and develop good modeling technique with an eye toward collaboration with other designers, correspondence with MIDAS IT if necessary and documenting decisions.
3. MIDAS will allow designers to integrate design routines, increase their understanding, allow for more precise modeling analysis and meet professional growth questions. To not take advantage of these features would not make sense.
4. Equally important is that MIDAS may save time. Integrating drilled shaft and pile design as part of full bridge modeling may save time in lieu of working with several independent programs. As skills and routines develop modeling either simple or complex bridges may take less and less time. Eventually maybe libraries of designs will evolve.
5. Simple bridges may not need the level of analysis provided by MIDAS in order to design effectively. We do not want to go down the path of creating work (or job time losses) on unnecessarily overdeveloped modeling.
6. Simple bridges provide for a good opportunity for working at LEVEL THREE since presumably their behavior while not more predictable than a complex bridge, may lead to understanding the behavior of a complex bridge which may have some predictability based on actual observations from the field. Simple bridges may not show any outward observable overstresses because of smaller scale.
7. MIDAS can analyze complex problems without having to reduce the problem. Complex bridge designs as performed now utilize simplifying assumptions. Keep this in mind when discussing modeling in MIDAS. However, MIDAS can perform complex bridge analysis more simply than by conventional methods. On the other hand, simple bridges may be overworked by MDAS. We will just have to see.
8. Complex bridges may provide for the opportunity of realizing cost savings by integrating the analysis and design of major elements, superstructure, substructure and foundations, i.e. integral design, full bridge design, recognizing structural connectivity influences each upon each other.
9. MIDAS can be scaled back to perform simpler analyses. For example MIDAS can do a continuous girder line simply supported using live load distribution factors as is current design methods. Or it can perform a continuous girder line with fixed ends as in a case of a presupposed actual integral abutment end confinement, or it can perform girder design as part of a full superstructure analysis with fixed ends and a deck as in the case of a full bridge model with integral abutments. Therefore the take-a-way is that simple bridges may not always mean simple MIDAS model. And conversely complex bridges may mean simpler MIDAS model.
10. Complex modeling will provide insight into structural behavior. Results should be scrutinized and rationalized. Pattern live loading is new for us. This is unconventional and a refined method of analysis used to represent secondary effects. Girder line loading is used now where distribution factors are used to represent.
11. **FULL BENT MODELING:**

In the beginning, MIDAS may be most useful in substructure analysis and design. Because the substructures (including foundations) and superstructures can be connected in MIDAS, the structural influence of each upon each other becomes determinable. Consequently, structural influence on the superstructure could affect its design. Currently, longitudinal and transverse bridge loading and girder reactions are placed on a substructure model where lateral deflection of the substructure is at least considered when distributing longitudinal wind, wind on live and braking loads to each substructure unit. Generally liberal assumptions are made regarding end bent lateral stiffness.

As another example, look at integral abutments and their unexploited structural influence on full bridge design. MIDAS can model integral abutments accounting for their influence of soil reaction where longitudinal displacement and girder rotations can be controlled for each stage of construction. The stiffness of an integral abutment should influence superstructure and other substructures of which it is integral with and part of the longitudinal framing of the full system. Now, only pile stiffness is used to account for integral abutment stiffness. Displacements are not typically checked and girders are assumed simply supported. Consequently, there will also be a structural influence on the superstructure from the substructure.

1. Division core training for new bridge designers should include both conventional and advanced design and programming methods. Veteran designers should learn new methods.
2. There is no intent to eliminate any structural software other than SAP2000 save one license for interfacing with Excel for our In-House Culvert Design program.
3. **MIDAS EXPERIENCES AT OTHER DOTs:**

In the early stages of investigating this software, several DOTs were contacted for their feedback after having purchased and integrated MIDAS CIVIL into their design culture.

One of them utilizes this software only for modeling checks on consultant work involving large bridges and complex structures. Another DOT uses this software as an optional/discretionary product for their conventional bridge design software regardless of the simplicity/complexity of the bridge (designer’s choice).

And finally, another DOT suspended their conventional software and design methods altogether in favor of utilizing MIDAS CIVIL. Most importantly, they said that in retrospect doing this actually had a negative impact on design and are now considering reinstating the conventional design methods based on gauging bridge complexity as to which method would be used. Their implementation was not planned, nor was their problem foreseen by them. Their advice is the rationale for having a plan. Hence, planning is the best way forward.

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**SHAREPOINT:**

A discussion library (we*blog*) for designer between designers called “MIDAS Blog” has been set up on the Development Section SharePoint site for questions, comments, responses, ideas, shortcuts and tricks related to using the software. Participation is encouraged and is voluntary. <http://sharepoint/systemdelivery/BR/development/Lists/MIDAS>

Another library called “?MIDAS? Emails” has been set up where designers can file (drag-n-drop) email correspondence between MIDAS IT. This will provide another repository of designer inquiry and solution (or resolution) from MIDAS IT.

<http://sharepoint/systemdelivery/BR/development/MIDAS>

MIDAS Guidance:

Formal development of a MIDAS manual is not planned. The task could be large and not necessary when set against a more approachable consequence seen as a user’s quick step guidance of best practice based on trial successes involving many users’ experiences, outcomes, checks and agreement, required preciseness and accuracy of model, etc. extracted from designer’s actual jobs using MIDAS or gleaned from the MIDAS weblog site (*read further*).

Rating:

Rating is performed using 2D girder line analysis and live load distribution factors. Any other more refined method of superstructure analysis and live loading distribution may produce results that are not within an acceptable margin of difference compared with 2D simplified girder line analysis, which is to say that 3D model refinement on the scale of a full bridge could produce under designed sections by more simplistic modeling and unacceptable lower ratings. This will need to be reviewed.

MIDAS CIVIL Customer Service:

MIDAS IT provides civil/structural/mechanical engineering software development along with analysis & design support. It is their claim that “One of our strengths is to respond to the needs of the practicing engineers extremely fast.” Please use the following email address for software support: tsmidasoft@gmail.com. (Or any other corporate e-mail address given when working with the MIDAS Technical Support Team)

MIDAS CIVIL Training Class:

If possible, specific structural design modeling problems will be made available to MIDAS IT for tailoring some of the software training to MoDOT. Expected time of training class will be mid-Summer or Fall.

On the National Scene:

Between the time of procuring MIDAS CIVIL licenses for the department and the writing of this guidance, MIDAS CIVIL is now a product owned by almost 30 DOTs. Whether all of this is changing the bridge design landscape at the state level is difficult to say, but questions about 3D modeling were included in this year’s AASHTO SCOBS Annual Questionnaire. Of course 3D modeling has been around for some time now, but its entrance into the DOT market niche on this scale is new. annoying

Comments or suggestions should be addressed to the Development Section.