LIFE Form Review

Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project Updates: Progress Ratings

Title	GP	OnC	NC	OffC	A
(01) Time related expenses model, based on combination of exter ...	1	7	0	0	1
(02) Exploratory investigation of field damage, hazard, and ins ...	0	6	0	0	1
(03) Empirical vulnerability model to assess impact of windborn ...	4	5	0	0	0
(04) Prediction of wind and surge damage to buildings by hurricane	2	6	0	0	1
(05) Probabilistic Modelling of Household Recovery after Hurric ...	0	6	0	0	1
(06) Development of Fragility Curves for Tornadic Loading on Lo ...	2	3	0	0	2
(07) Investigation of installation and anchor requirements of r ...	2	3	0	0	1

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Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (01) Time related expenses model, based on combination of exterior, interior, and contents damage

Phase: Project Update

Project PI: Jean-Paul Pinelli (Florida Institute of Technology)

Progress Ratings
Great Progress - 1
On Course - 7
Needs Change - 0
Off Course - 0
Abstain - 1

Summary of Responses to IAB Comments

Jean-PaulPinelli's Response: Thanks for your comments and suggestions. Glad to see so much interest. We'll be in touch soon with the mentors to request more input and guidance.

Questions

- Below are not necessary the question for the research but some questions we encountered previously and might be relevant to this research.
  Will we consider repair sequence explicitly (certain repair needs to happen prior to certain)?
  Will we consider the possible shortage of resources after a large disaster?
  Will the effect of damage of different components on downtime and repair depend on the location of the component and relative to building geometry? And will that be considered?
  Will we consider the constraint of workers and how to optimize the workers through different types of repair and different floors, areas, etc. to have the shortest repair time given the limitations of the workforce?
  For the interaction of utility downtime, will we do a network assessment explicitly? Or this is more like looking at a single building, as the network might be important when we have a portfolio of buildings.
  - Ben Shao (Arup, San Francisco office -)

  Response 1: The answer tot he first 2 questions is yes.
  Answer to question 3 is maybe. Beware that the data on "location of the component and relative to building geometry" is in general not available. There is NO data available in the exposure data on interior components and contents.
  Question 4: yes. These are so called scale factors.
  Last question: given scope, budget and time, we can only superficially estimate utility impact. The idea is to do a network assessment based on existing methodologies in the literature. That could be the subject of a follow-up project by itself. -Jean-Paul Pinelli
  Response 2: ok -Jean-Paul Pinelli

Suggestions

- It's not clear to me that this work is immediately relevant to GAF's interest.

- Erica Sherman (GAF -)

  Response 1: No comment -Jean-Paul Pinelli

- Comparisons with FCHLM outputs for relativity comparisons
  - Tim Johnson (AIR-Worldwide -)

  Response 1: yes, we are planning to do that. -Jean-Paul Pinelli

- Again very interested in this. And Arup has developed the REDi downtime assessment system (around 2013) which has been used by earthquake industrial to assess the downtime which might be relevant to your research. Happy to engage more.
  - Ben Shao (Arup, San Francisco office -)

  Response 1: Great. We might contact you to know more about it. Looking forward to have you join the WHIP-C! -Jean-Paul Pinelli

Comments

- Good progress and summary of what has been done so far. I do agree with you on validation that it can get tricky in the absence of claims data and also the time constraints. However, if you can still aim for some amount of validation by comparing your output with those from HAZUS, other vendor models through the publicly available FHLPM documentation, that would be great.
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: Yes, this is what we are planning to do. -Jean-Paul Pinelli

- It looks like good progress is being made towards the goal of completion for Summer 2022, thank you.
  - Erica Sherman (GAF -)

  Response 1: thank you -Jean-Paul Pinelli

- An interesting topic, work started in Sep 2021, early stage, no comments.
  - Xin Hai (Bechtel Energy Inc -)

  Response 1: no comments. -Jean-Paul Pinelli

- We have an indirect interest in this research. We will watch with interest.
  - Eric Haefli (State Farm Insurance -)

- Good progress and it seems like you have identified clearly your path forward. Non-residential occupancies will not follow in the framework you described, but that seems to be outside the scope of this project at this point (but would be of interest in to us in the future). Recommend trying to find some sort of metric to gauge the model performance given the absence of claims data.
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

  Response 1: Yes, non-residential TRE could be the subject of a follow-up project. -Jean-Paul Pinelli
  Response 2: Response 1: Yes, non-residential TRE could be the subject of a follow-up project. -Jean-Paul Pinelli -Jean-Paul Pinelli

- On course
  - Tim Johnson (AIR-Worldwide -)

- Downtime assessment is an extremely important part of wind risk assessment. Our group in Arup does downtime assessment of building structures considering different types of hazards a lot. So this topic is very relevant to what we do.
  - Ben Shao (Arup, San Francisco office -)

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Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (02) Exploratory investigation of field damage, hazard, and institutional data for potential use in risk models

Phase: Project Update

Project PI: Jean-Paul Pinelli (Florida Institute of Technology)

Progress Ratings
Great Progress - 0
On Course - 6
Needs Change - 0
Off Course - 0
Abstain - 1

Summary of Responses to IAB Comments

Jean-PaulPinelli's Response: Glad to see the strong interest in this project. Pleas,e feel free to continue sending suggestions via email as needed. We'll plan to meet with the mentors soon too.

Questions

- What feedback do you need from us to help facilitate your progress?
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

  Response 1: At this point, the best will be to meet with the mentors to get feedback. -Jean-PaulPinelli

- Research plan tor survey
  - Xin Hai (Bechtel Energy Inc -)

  Response 1: Not sure what the question is. Yes, we have a plan for the survey. -Jean-PaulPinelli

- One set of questions came to mind today. Are we looking at all types of wind events, tornadoes, hurricanes, derechos, etc. When it comes to larger events like hurricanes, determining the geographic extent of data collection is interesting. Impact extends further than tropical storm winds. Plus, will the hazards include rainfall, wind, flooding?
  - Eric Haefli (State Farm Insurance -)

  Response 1: In part, many of these questions will be answer by the exploratory study. Potentially, such a project could extend to any type of wind-related hazard. -Jean-PaulPinelli

Suggestions

- From what you spoke of, I would be interested in gaining a better understanding (overview) of the existing tools if that isn't too time-consuming.
  - Eric Haefli (State Farm Insurance -)

Response 1: yes, that is one of the objectives of the exploratory study: to investigate what tools are out there available. I think the main source of tools will be the Sim-center from NHERI. We have not gotten to this part of the study yet. -Jean-PaulPinelli

- I'd be curious to see the outcomes of the review on current practices for data analysis and visualization techniques at the next update.
  - Erica Sherman (GAF -)

  Response 1: ok -Jean-PaulPinelli

Comments

- Very excited for this project and strong believe this will go a long way in helping companies like our use this data more meaningfully and in a quantifiable way.
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: Thanks -Jean-PaulPinelli
  Response 2: OK -Jean-Paul Pinelli

- I think intersecting footprints from wind, surge and precipitation induced flooding would be awesome. This is inline with the comments from Eric and Tim.
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: OK. -Jean-PaulPinelli

- My team reviewed some of the earlier information for this project that was provided over the summer, and there is strong interest in what you have proposed. It looks like the progress is on target and the scope meets expectations.
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

  Response 1: Thanks -Jean-PaulPinelli

- Identify the data related to building damage & hazard, help insurance to evaluate the damage level. At early stage, work just started in fall 2021, no comments.
  - Xin Hai (Bechtel Energy Inc -)

- Looking forward to gaining a better understanding what all is out there now and how to coordinate or improve data collection.
  - Eric Haefli (State Farm Insurance -)

- It looks like everything is on track.
  - Erica Sherman (GAF -)

- It would be useful if the project-team could achieve usable deliverables already at the end of the first assessment
  - Maurizio Savina (SCOR -)

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Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (03) Empirical vulnerability model to assess impact of windborne tree debris on low-rise construction

Phase: Project Update

Project PI: Amal Elawady (Florida International University)

Progress Ratings
Great Progress - 4
On Course - 5
Needs Change - 0
Off Course - 0
Abstain - 0

Summary of Responses to IAB Comments

AmalElawady's Response: The major takeaways are mainly related to enhancing the current preliminary Monte Carlo simulation models by accounting for the failure of tree branches and other possible failure modes. Also, some comments were made regarding the inclusion of the additional mass from the rain. We will study how wind-driven rain impacts can be taken into consideration. The next phase is focused on translating the tree vulnerability data into buildingsâ€™ exposure indexes.

Questions

- I would imagine the presence/absence of leaves, how wet they are can impact the mass that's on top of the trunk and can exacerbate damage. Can this be accounted for using a mass factor even if you don't contemplate this in an explicit fashion?
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: Thanks for raising this important point. Currently, the model does not include the effect of the crown mass when estimating the stresses. We plan to include this factor in the next phase of this year. Adding the effect of wind-driven rain effect can be very important too and we believe it may affect the crown mass and more importantly the total forces on the tree (from both wind and wind-driven rain). We will work on this to see how this can be accounted for. Wind tunnel testing and wind-driven rain testing will be important to validate the assumptions made. -Amal Elawady

- Missing data is a problem. Is there any possibility of studying tree failures in past events using aerial imagery?
  - Eric Haefli (State Farm Insurance -)

  Response 1: Thanks for the comment. We are already considering available damage assessment data for trees to validate our models. We have damage data for two tree species. For the data missing such as crown diameter, etc for some trees we have, we try to find information from literature and satellite imagery database to complement our database. However, we think site visits can be the solution. We will talk to our mentors to check if such data is available elsewhere. -Amal Elawady

- For the failure of tree: do you have the level of damage?
  - Xin Hai (Bechtel Energy Inc -)

  Response 1: Thank you for this comment. The focus of this project is the windborne debris effect of falling trees. So, we are only looking at the damaged trees and we are currently investigating the possibility of including failure of branches. -Amal Elawady

Suggestions

- I'd be curious to see the outcomes of the review on current practices for data analysis and visualization techniques at the next update.
  - Erica Sherman (GAF -)

  Response 1: I think this question is related to another project. -Amal Elawady
  Response 2: Yes, hopefully we will have more to share at the next meeting. -Jean-PaulPinelli

- I think taking this information and combining it with vegetation cover surrounding a building and translating that to debris sources and what damage they can potential inflict on buildings will go a long way.
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: Thanks for the comment. I totally agree. This is the plan for the next phase of this year and year 2 (if funded). We will discuss with our mentors what could be the best output formatting to target to merge the data on tree vulnerability together with the building's exposures and potential risks. -Amal Elawady

- At some point, it will be necessary to study uprooting failures.
  - Eric Haefli (State Farm Insurance -)

  Response 1: Thanks for the comment. We agree. We will investigate this failure mode and assess whether we can include this in year 1. Wind tunnel/structural testing can be a great tool to assess in answering this question. -Amal Elawady

Comments

- It appears that things are on track.
  - Erica Sherman (GAF -)

  Response 1: Thank you! -Amal Elawady

- Thanks to Amal for an excellent summary on the progress.
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: Thank you! -Amal Elawady

- It looks like good progress is being made.
  - Erica Sherman (GAF -)

  Response 1: Thank you! -Amal Elawady

- I like the attempts of correlating crown diameter to trunk diameter, tree height, etc. I think this is groundbreaking work. So much to do.
  - Eric Haefli (State Farm Insurance -)

  Response 1: I agree. It was important to find out about these correlations. Thank you so much

for the positive feedback! -Amal Elawady

- Methodology seems well established. Seems like there will be connections to projects such as time element estimation or power outage modeling in the future.
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

  Response 1: Yes, these models can help in different ways. Thank you so much! -Amal Elawady
  Response 2: Yes, there is potential for man applications. -Jean-PaulPinelli

- While not directly applicable to my area (design of industrial structures - we tend to clear a lot of land), I am very impressed with the practical application to the design / land management / risk management professions. My home is surrounded by a number of 65' high pine trees in Northwest Harris County (Houston area) and much of the damage we see (and power/utility loss to businesses and homes) is due to failures of trees.
  - J. G. (Greg) Soules (CB&I Storage Solutions -)

  Response 1: Thanks for sharing this. I agree; I have seen similar damage scenarios during reconnaissance efforts post Hurricane IRMA. -Amal Elawady

- Evaluate the tree damage for more than 32% of 40,000 tree data.
  Monte Carlo simulation is used to compute the rate of tree damage with a range of wind speeds, in order to evaluate the damage level.
  - Xin Hai (Bechtel Energy Inc -)

  Response 1: Thanks for summarizing the progress. -Amal Elawady

- Great progress
  - Tim Johnson (AIR-Worldwide -)

  Response 1: Thank you! -Amal Elawady

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Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (04) Prediction of wind and surge damage to buildings by hurricane

Phase: Project Update

Project PI: Doug Smith (Texas Tech University)

Progress Ratings
Great Progress - 2
On Course - 6
Needs Change - 0
Off Course - 0
Abstain - 1

Summary of Responses to IAB Comments

Questions

- 1) For the validation, are you looking at one, some, or all 16 building systems?
  2) For estimating interior damage, are you going to use the 500 claims to develop a method of estimating interior damage?
  - Eric Haefli (State Farm Insurance -)

  Response 1: I am looking at all 16 components.

  It is my intention to look at interior damage as well. This is a complex issue as some interior damage can occur due to "failures" that are not considered in the structural model. For instance, water infiltration through windows due to wind is not explicitly addressed in the structural model/performance functions. -Douglas A Smith

- How does this project relate to, complement, or differ from the hazard model that is being developed under the COASTAL Act to determine wind vs. flood damage for NFIP purposes?

  What kind of liability might be associated with use of this project's model to adjust insurance claims?

  Other than TWIA, why did IAB members give so few options for validation points? That's disappointing.
  - Tanya Brown-Giammanco (NIST -)

  Response 1: It is my understanding that the current status of coastal act is that the wind model(s) from NWS is nearing completion and that the damage prediction part has not been started by FEMA. That being said, I cannot directly compare the two methods.

  Regarding liability, this methodology has been used in court cases for Katrina and used to settle claims for Hurricane Ike and one other hurricane in Florida. I am not an expert in liability, but when I used the methodology as an expert witness, my liability was to due my due diligence and use the state of the art methods. Liability for a large firm, I do not know the answer for that

case.

Regarding the validation dataset from IAB members, they originally were going to provide data. When the TWIA dataset became available, it made sense to start with this dataset and see what results we get and then fill in gaps in data with what IAB members can provide. TWIA has also offered to provide additional data. -Douglas A Smith

- There are several questions that we have in our approach which might not be directly relevant given this research scope, however, I just like to put here in case that can be addressed:

  1. Totally agree that ASCE 7 pressure coefficient is not quite accurate in many aspects when doing damage assessment. We understand wind tunnel could be done. However, will the wind tunnel test conducted in the research can be easily used and extrapolated for other similar structures in a simplified manner? Other types of components other than roof?
  2. Is the rain damage considered in the research besides surge, which depends on the envelope failure. If so, how the rain-wind hazard correlation has been established in the study.
  3. How the wind resisting capacities for different failure mechanisms of different types of components are determined. It is always challenging for us to establish these capacities based on the build condition, construction year, specific construction type, etc. Which significantly affects the final failure results.
  4. In the damage model, you mentioned the consideration of terrain. Is the local surrounding also considered? For example, there are multiple buildings next to each other which might induce a significant local wind effect when calculating the wind pressure.
  - Ben Shao (Arup, San Francisco office -)

  Response 1: The University of Western Ontario wind tunnel data used in this research is publicly available from NIST. There are many datasets there. They can be analyzed and reduced to whatever simplified form the analyst desires. There is considerable work in doing this however.

  Rain hazard is not explicitly addressed in this work.

  Nominal wind resisting capacities are determined from manufacturer's and other public information. Texas Department of Insurance has a website with lots of testing results. These nominal strengths are reduced by construction, component and age factors to achieve the final strength used in the analysis. Code based strength can also be incorporated in resistance but in not currently in this model.

  Local wind effects that you describe are not included in this model -Douglas A Smith

Suggestions

- For porting MATLAB to Python, can you find a gifted graduate student (maybe from Computer Science) to do the porting.
  - J. G. (Greg) Soules (CB&I Storage Solutions -)

  Response 1: Thanks for the suggestion. I have used computer science students for developing data processing programs and similar projects that don't require a strong background in structural engineering and reliability. My experience with computer science students is that they are good at data science and some limited scope projects. I have not had good luck with them doing detailed structural engineering work/programming. Further, this is inside baseball so to speak, the Dean of the College of Engineering expects that once you hire a research assistant that you support them until they graduate. This implies if I hire one, if the the project

is completed in 6 months and he has 12 additional months before he graduates, then the expectation is that I support him for the 12 months till he finishes. This is difficult to do considering the structure of the IUCRC projects which go year to year. -Douglas A Smith

- Very interested in this research, and happy to engage more if possible. Especially on the progress and improvement on the pressure calculation for envelop component out of this research.
  - Ben Shao (Arup, San Francisco office -)

  Response 1: Will be happy to collaborate -Douglas A Smith

Comments

- To value building damage due to wind, surge and hurricane, developed a damage algorithm. Very interested topic, and can be widely applied to industry building.
  - Xin Hai (Bechtel Energy Inc -)

  Response 1: Thanks -Douglas A Smith

- I think your work is very valuable and will be very valuable.
  - J. G. (Greg) Soules (CB&I Storage Solutions -)

  Response 1: Thanks -Douglas A Smith

- Incorporating claims data and drilling into the details of roof structure to enhance the model looks promising.
  - Erica Sherman (GAF -)

  Response 1: Thanks, I hope it is fruitful. -Douglas A Smith

- I am amazed every time I see a presentation by Doug. What a complex problem to tackle!!

  I am so much more concerned with validation than concerned with graphic user interface. Keep going in the direction you are going.
  - Eric Haefli (State Farm Insurance -)

  Response 1: Thanks. Validation is the key to the project. Granularity of the data will be the key. -Douglas A Smith

- Very good progresses, however to me it seems more validation is required.
  Validation is key to make use of the model for business decision, hence i'd suggest the project-team to demonstrate the validity of the deliverable against real-world observations.
  - Maurizio Savina (SCOR -)

  Response 1: That is the plan. To a basic degree, the base model developed for TDI and implemented by Texas Windstorm Insurance Association has been validated using claims. This round of validation will be more granular and look at effects of model vs reality. -Douglas A Smith

- Inclusion of validation data is a great alteration. Plan and progress meet expectations as proposed. One aspect of using claims information to consider is whether additional expenses that are paid other than direct physical damage can be identified (claims assessment costs, debris removal, additional living expenses, etc.).
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

Response 1: Good idea. I will see what can be accomplished in this regard within the time and dollar constraints for the project. -Douglas A Smith

- The research is very relevant to what we do. In Arup, we do wind vulnerability modeling of building structures at the component level to understand the failure, the downtime, and risk, and provide practical mitigation to lower the risk.
  - Ben Shao (Arup, San Francisco office -)

  Response 1: Thanks for the input -Douglas A Smith

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Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (05) Probabilistic Modelling of Household Recovery after Hurricane and Wind Disaster

Phase: Project Update

Project PI: Brad Ewing (Texas Tech University)

Progress Ratings
Great Progress - 0
On Course - 6
Needs Change - 0
Off Course - 0
Abstain - 1

Summary of Responses to IAB Comments

Questions

- 1) What are examples of a few questions, potential answers?
  2) Do you quantify things about the household like the number of occupants in a household? Age of home? Amount spent per year in maintaining their home?
  - Eric Haefli (State Farm Insurance -)

  Response 1: Regarding (1) - we plan to share more questions later but here is one on disaster preparation:
  25. What mitigation/precautionary measures did you take before the Hurricane/Typhoon XXX? (check all that apply)
  1. Storm shelter installed
  2. Structural fortification
  3. Protection of openings
  4. Other (please specify) _____

  In terms of (2) - yes to occupants and a number of questions regarding type of house... we plan to add expenditure data on repairs, etc. but "average" expenditures would be good to as we can then normalize the repair responses. -Brad Ewing

Suggestions

Comments

- Develop a survey for people to response the damage recovery time due to the hurricane, tornado, windstorm event. The survey will provide the mean time for household recovery
  - Xin Hai (Bechtel Energy Inc -)

- Seems the project is progressing well, looking forward to the results.
  - Maurizio Savina (SCOR -)

- 1) We have found that very, very few people take preemptive, proactive actions to reduce the impact of future natural disasters.
  2) Interesting project.
  - Eric Haefli (State Farm Insurance -)

  Response 1: Regarding (1) - this is a good point. We may be able to identify regular everyday actions some people take that mitigate the wind event/hurricane impact as well as those more intentional actions. -Brad Ewing

- This looks like interesting work and good progress.
  - Erica Sherman (GAF -)

- Progress looks to be on target. We are looking forward to see the types of results you get from this project, as it is a cost effective way to augment results from other similar projects.
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

  Response 1: Agreed. We see this as a way to validate and support any number of (often) costly engineering alternatives. -Brad Ewing

- On track. Look forward to the results.
  - Tim Johnson (AIR-Worldwide -)

LIFE Form Review

Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (06) Development of Fragility Curves for Tornadic Loading on Low-Rise Buildings

Phase: Project Update

Project PI: DeLong Zuo (Texas Tech University)

Progress Ratings
Great Progress - 2
On Course - 3
Needs Change - 0
Off Course - 0
Abstain - 2

Summary of Responses to IAB Comments

Questions

- Can your work be incorporated into the new tornado provisions that will be published in the 2022 edition of ASCE 7?
  - J. G. (Greg) Soules (CB&I Storage Solutions -)

Suggestions

- Very curious to learn the general findings of this research. E.g. the amplification factor one should use on pressure coefficient for tornado assessment at various conditions, how to consider internal pressure.
  - Ben Shao (Arup, San Francisco Office -)

Comments

- Impressive research.
  - J. G. (Greg) Soules (CB&I Storage Solutions -)
- I think it's really helpful to distinguish the differences between tornado and hurricane on building performance in this way, including the effect of background leakage. Understanding how to connect this to practical building component design and building code will be critical.
  - Erica Sherman (GAF -)
- Very interesting results and there seems to have been considerable progress on the testing side. It's good you have already begun discussing how to translate the test results into comparative metrics specific to damageability. As we have discussed in interim meetings, our interest is higher for low rise commercial structures than residential (although we are interested in that, too), so any consideration along those lines is appreciated.
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

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Wind Hazard and Infrastructure Performance (Texas Tech University) - October 28th, 2021

Project: (07) Investigation of installation and anchor requirements of roof systems under high wind conditions

Phase: Project Update

Project PI: Arindam Chowdhury (Florida International University)

Progress Ratings
Great Progress - 2
On Course - 3
Needs Change - 0
Off Course - 0
Abstain - 1

Summary of Responses to IAB Comments

Questions

- What are your plans to get your work introduced into ASCE 7?
  - J. G. (Greg) Soules (CB&I Storage Solutions -)

Suggestions

- It would seem that many other companies, who are currently outside the IAB, would be interested in this. For example, coping manufacturers, roof membrane manufacturers. Might want to get the word out through presentations at conferences.
  - Eric Haefli (State Farm Insurance -)

Comments

- Very valuable research.
  - J. G. (Greg) Soules (CB&I Storage Solutions -)

  Response 1: Thank you. (comment by Soules) -Arindam Chowdhury

- Great summary of the plan and objectives of the study, test set up etc.
  - Karthik Ramanathan (AIR Worldwide -)

  Response 1: Thank you. (Comment by Ramanathan) -Arindam Chowdhury

- 1) One failure mode that I've seen in the field with low slope roofs is pressurization of the space between the roof deck and roof membrane. Just pointing that out without knowing if that is something important.
  2) Failures at roof perimeters are common. There are even many videos where this can be seen.
  3) RICOWI (Roofing Industry Committee on Weather Issues) might be very interested in your work. Might want to do a presentation at an RCI conference.
  4) Excellent work again from FIU.
  - Eric Haefli (State Farm Insurance -)

Response 1: Thank you for your valuable feedback. We will consider these comments and discuss with the mentors. (comment by Haefli) -Arindam Chowdhury

- Looking forward to seeing the testing results as they come out. The influence of vibrations on the damageability is interesting.
  - Tim Doggett (Berkshire Hathaway Specialty Insurance -)

  Response 1: Thank you. (comment by Doggett) -Arindam Chowdhury