Exploring Project Challenges and Opportunities

Technical Report III

AE 481 W

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Executive Summary

Technical Report III focuses on exploring project challenges and opportunities. Issues related to the project management will be discussed in detail along with the some of the contemporary construction issues that were debated in PACE.

To learn more about the challenges and opportunities in the Whitmore Laboratory Renovation Project, an interview has been scheduled with the project engineer, Abby Krieder. During the interview, we discussed the services Barton Malow (CM) performs and how they contribute to the facility design, construction, and operation. In addition, we touched upon how the project team would deal with issues related to schedule delay or subcontractor default. Then, value engineering topics were brought up to the conversation.

In PACE, the program was a day long where the students got the opportunity to interact with industry professionals. First Dr. Amor talked about the life after BIM revolution and viewed his opinion on the current statue of the industry. Then two breakout sessions were held where students along with the professionals discuss some of the current research topics. Also a panel discussion was held which was very helpful for the students to gain awareness of the challenges they will face at the beginning of the career path. At the end of the conference, every two or three students met with an industry professional to discuss the students interest research topics and develop better understanding of these topics.

Finally, LEED evaluation of the project is presented in this paper. The student suggests sustainable practices based on the project circumstances and evaluate the appropriateness and efficiency of these suggestions. Then the actual practices are compared with the proposed practices and critically discussed.

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Project Manager Interview

Project Management Services

Barton Malow was awarded the job as a CM in Fall 2012, which included Muller and Whitmore Laboratories. Barton Malow joined the project team after the design was complete, so they did not perform any services towards the design. However, Barton Malow reported some changes that should be done based on field conditions. They also helped the owner selecting subcontractors considering the best value. After selecting the subcontractors, Penn State and Barton Malow all together would negotiate the scope of work and they may change the cost per the agreement with the subcontractor. Some of the subcontractors are repetitive but the biggest two subcontractors (North Central Mechanical and Westmoreland Electrical) are hired for the first time by Barton Malow. Also the CM is responsible for the general conditions such as: existing conditions, site fencing, maintaining safe site, offices, and housekeeping when necessary. There are 3 workers under Barton Malow who are full-time every day in site. Their responsibility is to help in the general conditions.

The biggest challenge Barton Malow faced in this project was hiring a mechanical contractor who they have no experience with. Besides, the mechanical contractor has never worked for Penn State before. So that created sort of uncertainty in the project team. The nature of the job in a laboratory building is very sophisticated due to the complication of the air circulation and balancing system. Additionally, this project has a unique lab room that was never built before. The special feature in this lab room is that it has 76 fume hoods. That will cause air balancing and noise issues, which is not acceptable for an educational environment. Penn State is not tolerant in its high standards for laboratory quality and capability. To solve this problem, Barton Malow added a buffer of one month at the end of the schedule to leave enough time for testing and balancing. If needed, there will be adjustment both to the fume hoods and the mechanical system. North Central Mechanical subcontracted Siemens for the mechanical controls. The project engineer, Abby Kreider, said the mechanical work is progressing very well and now they are in the testing process. Another challenge during the project was falling behind schedule. In order to accelerate the work, there was overtime and weekend work. The extra cost resulted from that was paid by the subcontractors or from the contingency depending on who is responsible.

The main challenge from the client side is to keep the building partially operating. That means students, staff, and faculty should have continuous access to the laboratories. Since the laboratories are specialized and have certain equipment, it is impossible to move the students to other buildings. Shutting down the entire building during Fall or Spring semesters is not an option because that would delay some students' graduation. As an exception, the construction team is allowed to close the entire building during the summer (May-September). That is why the construction had to be phased into two phases. The east half of the building is accessible

by students while the west side is kept closed for construction. It is the other way around during phase two.

Value Engineering Topics

There are two main value engineering solution that Barton Malow suggested.

First, light fixtures in the basement were intended to be reinstalled after renovation but it turned out that they do not comply with the code any more. Therefore, Barton Malow proposed change order that suggests replacing the light fixtures. Not to mention, the old fluorescent light fixtures will be replaced with LEDs. Obviously that would increase the cost. To counter the extra cost, Barton Malow recommended changing the light switches in the mechanical room from dimming switch to on/off switches. That being said, there will be cost saving by installing basic light fixtures and switches. It is more reasonable to have on/off switches in the mechanical room because such a technician or operator will need the full brightness or none.

Secondly, there was a debate between two individuals from the Environmental Health and Safety office (EHS). The first one was concerned about energy loss from the exhausted air and wanted the fume hood face velocity to be 60 fpm. Opposing him, the other one who was worried about the health and safety in the learning environment and wanted the fume hoods to exhaust as much air as possible, 80 fpm. Barton Malow compromised both sides and set the face velocity to 70 fpm.

Critical Industry Issues

Partnership for Achieving Construction Excellence (PACE) is held annually in Penn State main campus. PACE opens the opportunity to showcase the newest technology of construction and discusses the contemporary issues related to the industry. Students find the opportunity to talk with key personnel from different companies from the industry. From the discussion with the industry professionals, students gather information and research ideas to investigate more in the second semester.

Keynote Presentation- Life after the BIM Revolution

Dr. Amor is a visiting professor for University of Auckland in New Zealand. He is the head of Department Computer Science. Professor Amor gave a fascinating presentation explaining his perception of BIM today and predicting its direction in the future. There are over 4,500 software tools developed for A/E/C/FM but around 1% that use IFC. That being said, interoperability between these tools is difficult and requires manual input, which is time consuming. However, in the future, it is expected that interoperability be easier and more tools will incorporate IFC or any language of its extensions. Dr. Amor also discussed some technical issues that are encountered nowadays such as: incorrect mapping and loss of information during interoperability process.

Panel Discussion: Enabling the Workforce: Hiring and Retaining Young Leaders

The discussion was centralized around the issues experienced by college seniors and young professionals when they start a job. The main challenges they face include: interacting with a verity of people from different ages, lack of experience and, limited background. In college, students tend to interact with peers who are in the same year and peruse the same degree. Yet, the situation in the field is totally different and that creates difficulty for fresh employees. Overcoming these difficulty is what makes the employee successful and indicates good career path.

The purpose of this panel is to raise students' awareness of the near future issues to make smooth transition from college to construction. The panel also advises the students to make connections in the beginning of the career to pave the road for them. Being a good fit the particular position in particular company is an important step to start a successful career path. The Panel teaches the students how to find the suitable job and what competencies the companies are looking for in their candidates. It was a great opportunity for us (students) to listen from firs-hands.

Breakout Session 1C: Distributed Leadership vs. Centralized Decisions

The session was about how leadership is horizontally integrated, rather than dominated by few executive individuals. Yet the leadership team comes to consensus and agree to a decision. While that being the main topic of the conversation, we touched on trust building within the team, which includes representatives from various trades. Collaboration is an essential competency in order to build a sloid communication platform. It also motivates the members to take responsibility in their field of specialty and allows the team to pay attention to details. Mainly the discussion covers two aspects: (1) who has the authority to make a decision, and (2) how collaboration should be shaped taking into account the project delivery method and contract type.

Different issues that occur during the project require involvement of different specialties. It is common that high rank individuals, such as: project director, project manager, and project engineer, would stick to their roles, rather than stepping up and a involving in other related issues. This creates uncertainty within the project team leading to reduced productivity. Job description of such a role does not confine that individual in that area, but personal competencies and talent should be employed in the work environment. That would complete add a lot of value to the project team resulting in increasing productivity. However, higher managerial personnel would not leave the decision for lower individuals unless the team members share trust. In an ideal case, such a decision should include everyone's input regardless of the result. Industry members involved in the conversation advised the students

to examine the team decision mechanism in different projects and observe how that contributes to the project's primary goals.

It was agreed during the discussion that collaboration is the driver for lean construction. The project team aims to reach the highest efficiency possible by incorporating effective teamwork. In reality, there is a large area for improvement regarding the collaboration and when it should start and how it should work. Some form in the market specifies the mechanism of collaboration such as: IPD contract. IPD is purposed toward the quality, efficiency of a project. It requires all the involved parties in the project to be cohesive and clear about their decisions, rather than working individually. Everyone is a winner in the IPD project because the decisions are made to benefit all parties. By distributing the leadership, the owner losses some of the leverage over the other disciplines. It also shifts portion of the risk to the owner side, but it generates potential benefits for the owner down the road. Looking at the management aspects, it is important to take measures of how fast paperwork is processed such as: shop drawing approval, inspections, and RFIs. And how would that reflect on the productivity. The taken measurements should be compared with the conventional contract types to highlight the add value in IPD contract. It also helps determining what practices should be adopted in other contract types.

Breakout Session 2A: Automating Design Analysis

Automated design analysis is a design process that is fully automated by computers. The purpose of this technology is to accelerate the design phase and reduce design cost. That is because a computer will be able to do the architect job. A computer will propose a design or more based on predefined rules. Automated design analysis mainly employs artificial intelligence to author designs built on the user preferences.

There are several potential uses for automated design analysis. First, designing the architectural aspects of a building. For example, building layout, size, orientation, configuration are developed by a design tool. Another potential use is structural design where the program can find the best appropriate structural system based on the different loads that the user inputs to the program.

Automating design analysis is not yet developed. Therefore the methodology is not more than a hypothesis that is still under test. The proposed methodology suggests that a machine would monitor the facial expression of an individual while s/he takes a virtual tour in a facility. The machine will interpreter the facial expressions into impression that will be saved in a database. Then these impressions are classified as positive, negative and neutral. Based on the positive impressions, the machine can detect what components of the building are satisfying and pleasing. Next, algorithm will be developed to use that information to propose a design. In order to collect the largest amount of data possible, there will be a central, cloud-based

database that different software tools will be able to access it. This methodology eliminates or minimizes entering data manually.

The discussion in PACE Roundtable focused on implementing automated design analysis in the architectural design. Dr. Asadi stated that 99% of residential buildings are similar in design. The majority of residential buildings have: master bedroom, bedrooms, living room, kitchen, bathrooms, and big open area in the basement. Since the components of the building are similar, it makes it possible to develop algorithm that would design an entire residential building. It was also brought to the table that a computer does not have necessarily to develop an entire design while it can propose a number of designs and sort them by cost, quality, size, energy consumption or other parameters. The discussion involved construction managers except for two people, one is architect and the other one is mechanical engineer. The construction managers believe this technology is going to eliminate time spent in authoring a design. That would expedite the project schedule and cost less due to the fact that architects and engineers have minimal involvement. On the other hand, the architect and the mechanical engineer argued that this technology would put human in idle status. Human intellect should be employed first with the help of the technology but not the other way around.

Feedback from PACE Industry Roundtable

The discussion was with Jonathon Lang and we discussed the implementation of BIM in his and my project. We also touched upon the mechanism they use for collaboration. The conversation notes sheet is attached in the appendices.

Leading Industry Practice Evaluation

Building Information Modeling Use Evaluation

The primary goal of using BIM is to improve the design, construction and operation of a facility. Different BIM uses are implemented in different projects depending on the circumstances of that project such as: company mission, client requirement, size of project, time scale, and technology available. When selecting BIM uses for Whitmore Laboratory Renovation project, it important to take into consideration, the project cost is $24.5 M, 15 month long, engineering systems replacement, building type is educational laboratory. Considering that, there are some potential BIM uses, out of the 25 uses, that would add value to the project. The recommended BIM uses for Whitmore Laboratory renovation projects are: 3D Coordination, Design Authoring, Design Reviews, Existing Conditions Modeling, and Digital Fabrication. An explanation, purpose, and process for each use is provided in the following lines. Figure 1 shows the implementations in a timeline scheme where Existing

Conditions Modeling, Design Authoring, and Design Reviews happen during the design phase where 3D Coordination and Digital Fabrication take place during the construction phase.

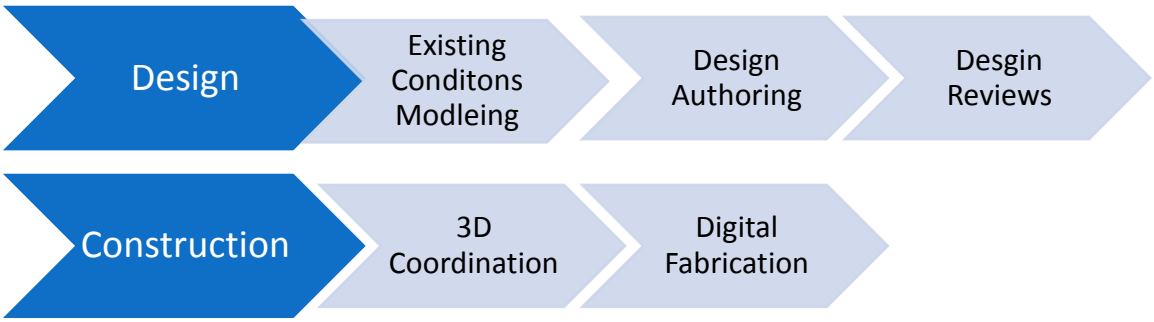

Figure 1- Potential BIM Uses Timeframe

Existing Conditions Modeling is a process in which the project team builds a 3D model of the existing conditions for a site, facilities, or a specific area within a facility. The process is extremely expensive because it involves high end equipment such as laser scanner. Since the original drawings of the existing building are available, they can be used to author a model. Existing Conditions Modeling has many benefits including but not limited to: offering a model for future uses, assist further design authoring process, and visualizing purposes. The process starts by collecting the current facility data including: floor plans, elevations, building cross section, site plan and any related data. The building systems are not important to include in this particular project because they will be torn down entirely. Once all the information is available, an existing conditions model should be developed using one of the authoring tools.

Design Authoring is the process of developing a 3D building information model based on the criteria that is important to the translation of the building's design. Design Authoring is a significant step that virtualize the facility for all stakeholders. It provides better control and quality control to of design, cost and schedule. It also improves quality control and quality assurance. To clarify the difference between Existing Conditions Modeling and Design Authoring, Design Authoring uses the model built during Existing Conditions Modeling and may add, remove or replace components according to the new design so the modified model represents the characteristics of the new facility. Then building systems are added to the last version of the model. The process of design authoring is initiated by obtaining a copy of the Existing Conditions Model. Schematic design structural and MEP models should be developed separately. The modifications should be applied to the existing model in order to obtain a schematic design architectural model. The next step is to create design development models for each discipline. And then a final design models should be developed and made available for construction.

Design Review is the process of viewing the design for the stakeholders to provide feedback to validate multiple design aspects. Theses aspects may include: evaluating the quality, assessing space aesthetics, acoustics, security, texture, and colors. Nowadays, many displays are available for this purpose such as: computer Aided Virtual Environment (CAVE), walk through in a 3D model, and oculus. The advantage of Design Reviews is that it eliminate the need for the expensive and time consuming mock-ups. Besides, different design alternatives may be modeled and illustrated clearly to the client. It also expedites the design review process. In addition, it communicates the design to the owner, construction team, and the end user easily. The process start by gathering information for operation and maintenance (O & M) review, compiling model for constructability review, and building a virtual mock-up. Then perform each of: O & M reviews, constructability reviews, and end user review. Finally the feedback from each entity should be collected and sent back to the corresponding discipline to make the adjustments.

3D Coordination is a process in which clash detection software tool is used during the coordination process to determine field conflicts by comparing 3D models of building systems. It is implemented mainly to prevent any clash from happening during construction. Clash detection is executed after design review is complete which may coincide with the construction phase. Yet, any conflict between the building systems should be solved before executing that task in the site. Some of the value the 3D coordination brings to the project include: reducing the amount of RFIs significantly, visualizing construction, increasing productivity, cost effective since change order is minimized, decreased construction time, more correspondence accuracy to the design documents. The process of 3D coordination starts by holding a meeting with the involved disciplines. The meeting should identify: sharing system, information required, protocol to address collision. Once the disciplines come to agreement, a central model should be developed to compile all the systems models. Then, the program runs a clash detection function. If any is found, the conflict should be discussed with the corresponding subcontractors to find a solution. The program usually finds hundreds of conflicts but actually not all of them are real conflicts and some of them can be fixed by the project engineer provided that the subcontractor is aware of the fix.

Digital Fabrication is utilization of digitized information to facilitate the fabrication of construction materials or assemblies. It helps ensuring the fabricator has a clear view of the order leading to less waste and rework. Digital Fabrication can extend to a further step where machines assemble the parts instead of doing it manually. It can be seen in sheet metal fabrication, pipe cutting, and structural steel fabricator. The use of digital fabrication minimizes tolerance through machine fabrication. It also increases productivity and safety while lead time is reduced. 2D drawings can be minimized. Digital fabrication process starts after the final design is complete. Once the design is approved, a model should be sent to the

fabricator who in turn interprets the model to readable files by the machine. Then these files are fed to the machine to cut the material.

Sustainability Implementation

Building a LLED certified facility has been a trend in the last decade. Now it became very difficult to meet LEED minimum requirements. Whitmore Laboratory was originally built in 1953 which made it challenging to achieve any LEED level by only renovating the engineering systems. It is required to have 100% outside air in a lab building which makes it energy consuming. Penn State prioritizes sustainability in their projects but this project would not practical to pursue LEED Level for it. However, there are many aspects of sustainability in the renovation project but they do not reach the extent where they would achieve LEED Certified. For example, the exhaust air passes through a heat recovery system, which in turn transfers the heat to the outside air.

Innovation and Design Process is associated with any creative, unique or exemplary performance levels that were achieved on the project. There is 11 points assigned for this category. The project team can earn these a good portion of these points due to the advanced management methods and coordination is used in this project. Since LEED is not considered in this project, no documents are committed to address the LEED points for each category, so no information is available of the actual points. Apparently the team can achieve 8 point out of 11 for this performance.

Location and Linkage address the location of the project and its relationship to the local community. Whitmore Laboratory can potentially earn 13 point out of possibly 24 points due to strategic location. Being located in campus gives it a high advantage considering the services available, security, and ease of transportation.

Sustainable Site encourages use of the property to minimize the impact on the site. There is 22 points assigned for this category. It would be great if the project occupies the smallest area possible to minimize the impact on the surrounding environment. As discussed in the second Technical Report, the project can go with a smaller site later on the project because they will need all of the occupied space. Whitmore Laboratory Renovation project would not earn many point for this category because the project is occupying relatively a large area. Possibly they can get 4 out of 22 points.

Water Efficiency encourages the efficient practice of water use, whether inside or outside. The outside depends on Penn State policy on irrigation and that is controlled by the OPP office. The inside use of water has to be quite high because the building has many laboratories, which is considered water consuming. The water used in the lab cannot be reused due to the fact that

it may be contaminated. The building however can use the roof to collect water and use it for irrigation or for toilets' flush. For this category, the project can get 3 out of 15 points.

Energy and Atmosphere address the energy efficiency, especially the building envelope and heating and cooling systems. The heat recovery system is an energy saver device which is very important in a laboratory building. It is also recommended to add another sustainable energy generator such as: solar panels or KEC evacuated tube. However, to increase the health and safety indexes in the building, more air should be exhausted which is energy consuming. For this category the building can achieve up to 1 point out of 38 points.

Materials and Resources requires the use of environmentally friendly resources. Since the building structure is to stay the same, a big portion of this category is missed. The other engineering system such as: the electrical, mechanical, plumbing and fire protection systems require mainly manufactured materials. That is being said, the project will not be able to earn many points from this category. However, it is possible to hire local subcontractors to minimize the waste of transportation. There is 16 points assigned for this category and the project can achieve 2 points.

Indoor Environmental Quality encourages eliminating pollutants and contaminants in the inside environment. This is achieved through proper ventilation, moisture control, and exhaust. There is 25 point assigned for this category. It is encouraged to have the largest amount of outside air possible but that compromises the energy consumption. Anyways in a laboratory building the air has to be 100% fresh air. The face velocity of the fume hoods can be adjusted. For this project the velocity has been set to 70 fpm instead of 80 fpm and that is to reduce the heating energy. This velocity is still meets the requirements but it is not the optimal face velocity. It is possible the building gets 5 out of 21 points.

Last but not least **Awareness and Education** of the clients of the sustainable aspects in the building. There is 3 points available for this category which can be achieved by educating the clients about the maintenance and operation of the building. The final clients are faculty, staff, and students who are well educated and have gone thorough lessons on how to use and maintain the equipment in the building. So the project can get 3 out of 3 point in this category.

Finally the sum of the suggested LEED point sum up to 39 which is not LEED certified.

Appendix I – BIM Uses Table

PRIORITY (HIGH/ MED/ LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES
HIGH	Reduce and eliminate field conflicts; which reduces RFI's significantly compared to other methods	3D Coordination
HIGH	Transparency of design for all stakeholders	Design Authoring
HIGH	Eliminate costly and timely traditional construction mock-ups	Design Reviews
HIGH	Enhances the efficiency and accuracy of existing conditions documentation	Existing Conditions Modeling
MED	Reduce lead time	Digital Fabrication

Planning
Validate Program
Owner | Programming

Schematic Design
Existing Conditoins Modeling
Architect | Existing Conditoins Modeling

Schematic Design
Perform 3D Coordination
Architect | 3D Macro Coordination

Schematic Design
Design Reviews
Owner | Design Reviews

Schematic Design
Design Authoring
Architect | Design Authoring

Design Development
Author Design Development
Architect | Design Authoring

Design Development
Perform 3D Coordination
Architect | 3D Macro Coordination

Design Development
Design Reviews
Owner | Design Reviews

Construction Documents
Author Construction Documents
Engineer | Design Authoring

Construction Documents
Perform 3D Coordination
Architect | 3D Macro Coordination

Construction Documents
Design Reviews
Architect | Design Reviews

Construction Documents
Digital Fabricatoin
Contractor | Digital Fabricatoin

Operations
Compile Record Model
Contractor | Record Model

End Process

Program Model

Schematic Design
Architectural Model
MEP Model
Structural Model
Civil Model

Schematic Design Owner Feedback
Schematic Design 3D Macro Coordination Model
Schematic Design 3D Model

Design Development
Architectural Model
MEP Model
Structural Model
Civil Model

Design Development 3D Macro Coordination Model
Design Development Owner Feedback

Construction Documents (WP)
Architectural Model
MEP Model
Structural Model
Civil Model

3D Design Fabrication Documents
Construction Documents (WP) 3D Macro Coordination Model
Construction Documents (WP) Owner Feedback
Record Model

STUDENT FORM

Nov 3, 15

Student Name Mazin Alrashdi

Session 1: Topic: ~~Innovation~~ ~~Safety~~ ~~Mechanical~~ ~~System~~ ~~Energy~~

Research Ideas:

1) ~~—~~ ~~8~~

2) ~~—~~ ~~—~~

Session 2: Topic: Automating Design Analysis

Research Ideas:

1) Fully automated interoperability

2) Artificial Intellegence replacing architects

Session 3: Topic: Distributed leadership Vs Centrelized Decision

Research Ideas:

1) Construction Company : centreelized Vs distributed leadership

2) Collaboration method : on cloud

STUDENT FORM

Industry Member: Jonathon Lang Nov 3,15

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic? BIM - what effective uses.

Cloud
Procore = online database accessible by every party in the project.

→ live model : during meeting.
→ Revit, Navisworks
→ PG scheduling then export it → navisworks

Project : Sitework → Underground
BIM : Underground → floors

Suggested Resources:

What industry contacts are needed? Is the information available?

→ more staff : PMs, CMs have background
→ Information Available from contractors & vendors
→ RFIs

Scott - Project Director

Safety Director - Jeff (not on site full time)

Tim - Project Manager

Matt - Superintendent

Project Engineer - Abby

Assistant Super - Drew

Office Management - Budget

Field Management, Trade Organization

Owner

Arch/Engineer

Barton Malon (CM)

GC

Mech

ETC.

Barton Malow

① - precon: after design, Bid ✓ sub best value; not the lowest cost. scope. Some subs are repetative fm muller. ME are different. First time. Tim

② - 3 full time everyday.

③ - Bringing new M cont. never worked in campus. Controls seimens brought for control.

→ 76 fume hoods; in one room

- phasing of the occupied by studens and staff.

- phasing req by PSU to graduate

→ Rear EN HS; Energy. heat relay Energ . fume hood 80 f/m 60 f/m 70 f/m

→ Never done it and find for 76 fh.

→ BFH noise during class.

→ BMC responsible for executing.

(J-D) Jun-Dec

Approach → Schedule (sumer-Dec) no lab Students graduating

It cant be moved to other place

→ Schedule accelerated; there was overtime & weekend

→ subs & psu paid extra. → LINKNOWN - TESTININ & BALA

→ Based on field condition & client need.

Fume hoods did not have variak 2/fh

→ 80 → 70 f/m | roofing.