Support of ACI Foundation Research—An Industry Profile

Recounting how a long career culminated in a substantial donation from Vilas S. Mujumdar

After more than 40 years of engineering in the private sector, state regulatory work, and federal research management, Vilas S. Mujumdar, FACI, has given back to the industry through many aspects of his career—which includes civil and structural design, project management, research, and teaching. His recent donation of $50,000 to the ACI Foundation will be earmarked to support research with a holistic approach. The following question-and-answer session touches on some significant highlights of his career that influenced his continuing desire to impact the industry across all disciplines.

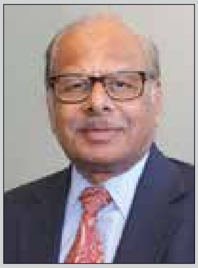
You participated in the construction of Habitat 67, an architectural icon in Montreal, QC, Canada. What was your role?

For Habitat 67, I was the project engineer for the precaster Francon, Ltd. I coordinated work with Habitat's design engineering firm of Monti, Lefebvre, Lavoie, Nadon & Associates, as well as the structural consultant on the project, August Komendant; and the architecture firms, Moshe Safdie and David, Barott, Boulva Associates.

How did you become the project engineer on such a monumental project?

It was serendipitous. When Francon interviewed me, I had no idea what Habitat 67 was. I had just moved to Montreal in the middle of January from London, England, for a different opportunity. I responded to a Montreal newspaper ad. The advertiser, Francon, was looking for someone who could design prestressed concrete, and it caught my attention because I already had experience in designing and building prestressed concrete bridges in India and the UK.

Someone from Francon soon called. The chief engineer picked me up, took me to Francon's office, and posed several questions. When he asked me to design something with a cantilever, I put the reinforcement on the correct side. He was



Vilas Mujumdar, FACI, is Professor of Practice, Iowa State University, Ames, IA, USA. His career has included 40 years in the private sector, 10 years in state regulatory work, and 6 years in research management. He has been involved in structural design, project management, university teaching, and research management. His experience includes designing and building long-span prestressed concrete bridges, designing cooling towers for the nuclear industry, and pioneering the use of precast concrete to sustain earthquake loads. Mujumdar is internationally recognized for his contributions to integrated, trans-disciplinary work in reducing natural hazard risks. At the National Science Foundation, he managed five engineering research centers.

Mujumdar is a member of the National Academy of Construction, a Distinguished Member of ASCE, and the author of two books. In 2019, the World Federation of Engineering Organizations recognized him with its Medal of Engineering Excellence.

He is a member of ACI Committees 369, Seismic Repair and Rehabilitation; 374, Performance-Based Seismic Design of Concrete Buildings; and 435, Deflection of Concrete Building Structures. He is also a member of Joint ACI-ASCE Committee 550, Precast Concrete Structures, and the ACI Foundation's Concrete Research Council.

He received his bachelor's degree in civil engineering from Vikram University, India; master's degree in civil engineering from the Indian Institute of Technology; MBA from Santa Clara University; and a doctorate in seismic risk from the University of Southern California.

Habitat 67, in Montreal, QC, Canada

impressed and asked me when I could start. I responded, "Well, I have another job in Montreal, but I will let you know in a couple of days."

After that time had passed, he called and said, "Look, we really need somebody like you who has done prestressed concrete." In brief, he offered me a lot more money than the firm that had attracted me to Montreal, so I took the job.

It was a typical precaster's office, with a bunch of people creating production drawings from design drawings. When I arrived, I was introduced to the project manager. He had a lot of experience with precast concrete, and he had moved from Manitoba for the project. Although I had a lot of experience with prestressed concrete bridges, I had no idea what precast concrete production people did. But I learned quickly.

What did you do as the precaster's project engineer?

My job was to coordinate precast production with the design and construction team. But the design was not complete. In fact, the project design continued throughout the project, and I had to identify problems in the incomplete design drawings so that we could complete the production drawings and produce the precast concrete. With every drawing, I had to coordinate issues with the production people, the construction people, the structural engineer, and the architect's office. This went on for about 3 months, and then we moved the whole office to the construction site. By that time, there were six engineers and 30 drafters, and increasingly, I was the person to resolve design issues with the structural engineering team and Komendant (who visited the project about once a week) and coordinate details with the production unit and the general contractor.

I was also involved very closely with Moshe Safdie's office, as they had assigned a senior architect to resolve production problems. Komendant had also assigned an associate, a partner to work in Montreal to solve problems.

As we were producing pieces based on incomplete drawings, I literally worked from 8:00 in the morning to 8:00 in the evening, every day. I had to sign off on every production drawing before the precast component could go to production. I had to make sure everything was going to work properly.

And we had lots of problems. I was the project engineer responsible for coordinating everything—the structural design, the architectural design, the general contractor's work, and the production team's work.

We were producing four units (using four forms for the apartment modules), and everything was a problem. I was not even 25, and I had barely 3 years of experience after my master's degree, but I enjoyed it tremendously.

How did you, a 25-year-old immigrant, prepare for such responsibilities?

My projects in India and the UK had been very long-span bridges with girders produced at the jobsite rather than in a factory and transported. These bridges included long post-tensioning tendons fabricated using the Lee-McCall System (known in North America as Stress Steel). Donovan Lee was the inventor, and McCall was the steel producer.

The Lee-McCall company was involved in the construction of prestressed concrete bridges around the world, and it was my honor to meet and work with Lee. I worked for the company on bridges in India and the UK for about 3 years. In both countries, the contractor wins the contract and designs the bridge. In such a system, the design engineer not only designs the structure and obtains approval from the government's engineers but also goes to the jobsite to see if there are any problems. In that system, I worked from design to construction, learning very quickly about overall problems.

So, when I got to Montreal, I knew regulations, how to solve problems in the field, and how to deal with people. That experience became critical when I started with Francon, because they didn't have anybody else like that, frankly. I also had experience with the post-tensioning system, as the Stress Steel system was used to post-tension the building's modules together (strands were used to post-tension the Habitat bridges).

What were some of the challenges of the project?

First, there was a time limit. Habitat 67 was to be a key part of the 1967 International and Universal Exposition (Expo 67), and it was coming soon. Second, it was not a simple building. Habitat 67 has 354 housing modules arranged in complexes of eight units joined in a very specific way, cantilevered this way, that way, and so forth. The eight-unit complex repeats in different shapes and different vertical and horizontal positions. But those eight units themselves were very complex. The eight different housing modules had fixed sizes (length, width, and height), but the structural design was not fixed. It varied, depending upon the module's location and imposed loads.

The modules included columns for vertical post-tensioning. Some modules weighed as much as 100 tons each, so there was a tremendous amount of crane work needed to lift them properly. That was the general contractor's job, but we had to transport the modules from a precast concrete factory. We furnished them completely after production, and then they were shipped, basically just transported by truck to the jobsite about a half mile away. There, the general contractor erected them.

Every week, our project manager and I had a meeting with the structural designers, who flew in from Pennsylvania, at the architect's office. But I had a list of problems every day. One drawing might show one thing, but another would show something else. I became a pain in the neck for the designers because I needed to know which drawing was correct, and the answer couldn't wait.

Komendant realized that there was a problem, so he took me to lunch to learn about my experience. I explained my experience with concrete bridges. I told him that although I had only 3 years of experience, I felt that I could do a good job coordinating with everybody because that's the kind of work I did. He replied, "I'm really glad that a person like you is here."

I was very honored to get to know him. He gave me a signed copy of his book on prestressed concrete design. And he even gave me a lecture on how he calculated the stresses in the modules. There were no computers in those days, so he determined the stresses using Airy stress functions. The designs were manually calculated—he even gave me a copy of his calculations.

Can you describe some of the more unique challenges?

When there were changes in the production drawings, I had to coordinate with six engineers and 30 drafters. I had to keep everyone informed of who was doing what and what was happening. And I had to sign off the production drawings.

The structural and architectural drawings were not coordinated, so we held weekly meetings to sort these things out. Keep in mind our production crew was waiting for the final production drawings, so we had to get this done. Sometimes, I would go to the plant and tell them to produce a different unit until we resolved some design issues. One of the bigger challenges was congestion. A column might have No. 10 bars vertically as well as post-tensioning ducts. The plant workers would say, “How can you pour concrete in this?” I couldn’t say, “Well, it’s not my design—I just communicate it.” I was the person at the site, and they were relying on me to figure it out.

Eventually, I convinced the design engineers that there were too many problems, so the design conglomerate assigned an engineer and put him on site to work with me to resolve problems in the design. That eventually worked quite well, and we had to do it because we could not solve everything in a weekly formal meeting.

“Throughout my career, right from the beginning, I did not look at any building as a project. I looked at my work as part of a system.”

Another unexpected problem was a change in the design requirements. After about 4 months of production of precast pieces, the design had to be modified. The city of Montreal suddenly determined that the building had to be designed for earthquakes. So, the design engineers called me and said, “We have to stop production.” We had already erected about half of the building. Fortunately, the designers convinced the code authorities that the overall design would conform to the seismic design, so we didn’t have to modify the existing structure. Even so, it was a very nerve-wracking thing.

In addition to increased post-tensioning in some units, the earthquake design resulted in a change at the interface between the column ends in stacked modules. To ensure more flexibility in the connections, we had to change from fully grouted connections to softer connections with 1/2 in. neoprene pads.

Lastly, it was hard to find qualified people. Some of the drafters had no experience at all. In fact, one of them had been working as a waiter before he started working on Habitat 67. Of the six engineers we had at Fabcon, two of them had a community college certificate. Although they were not engineers by training, they were able to identify problems in the drawings. Two other engineers were experienced engineers from Europe, but they were not experienced in the precast concrete industry. It wasn’t our job to argue over the quality of the structural design. Our job was to get it built.

If you could have made changes to the project, what would be different?

It’s kind of a difficult question to answer because I think how I’m looking at it is contextually different now as compared to what it was then.

What I would really like to keep is the creative combination of the units. For example, the eight-unit complex provided individual balconies. But I would modify the design to reduce the dimensions of the units which were so large and became so heavy, weighing about 100 tons—keeping production in mind.

This was a project which won an architectural competition. It’s a unique project. As exciting as the project was, it was really not suited for the efficient production of precast concrete. It needed to be designed to allow more uniformity, not so much distinction between units. I would not create the long bridges to connect the various units, because that complicated the whole thing. This was precast concrete production, after all. And keep in mind that the original concept was to construct 1000 units for the given budget, but this was reduced to 354 units because of the high cost caused by the uniqueness. That’s why this kind of project has not been repeated ever again.

How did the project influence your career?

I think it influenced my career tremendously. After Habitat, I worked with Spancrete in Montreal for 2 years before moving to Boston to be general manager for a precast concrete producer. I had no idea what I was going to do, but they said they wanted me because they had heard so much about Habitat; and nobody in the United States had that kind of experience.

In 1969, a program called Operation Breakthrough was started within the U.S. Department of Housing and Urban Development. This department was headed by George Romney, whose experience included being the president of American Motors and the governor of Michigan. Operation Breakthrough was a very large federal government housing program under which companies would be given contracts to produce housing units in factories.

We submitted our proposal thinking that our political connections through the owner of the company would give us a good chance. There were hundreds of submissions. Only 28 contracts were awarded, and we didn’t get one. Although we lost, my career continued in the design of several precast concrete projects. Later, the major associates of another company were hired by a unit of Westinghouse to submit a proposal to make a bid to construct housing in the Stuyvesant area of New York City. They hired William (Bill) James LeMessurier Jr. as a consultant. However, his company had nobody with experience in this kind of thing, so LeMessurier invited me to lunch and we discussed the project. He offered me a position and eventually agreed to meet my salary requirements. LeMessuier and I became very close because we were working on this exciting project with Westinghouse and with an architectural firm in Boston. We also developed several other design projects in precast concrete. He would introduce me as “Mr. Precast.”

And then, I copyrighted a design for a low-rise housing system. I also got deeply involved in precast concrete and in the Precast/Prestressed Concrete Institute (PCI). In fact, I was on the panel that wrote the first edition of PCI's *Design Handbook* in 1971.

In most of the world, governments control housing construction. They would say, for example, that they wanted 1000 units here or 1500 units there, and private companies would take on the projects. The same companies thought that they could repeat the experience in the United States under the Operation Breakthrough program. It did not work, however, so lots of companies lost millions of dollars. And they left the U.S. housing industry by the late '70s. However, Westinghouse continued to develop some units. We produced some in Connecticut and in Bedford-Stuyvesant.

We also did work in Memphis, Tennessee on a senior housing complex. At that time, Tennessee had just changed the code to include earthquake resistance, but the local code official didn't want to require it. Although we made it clear that we had already done this in Boston, the building official said, "I don't care what you do in Boston. We're in Memphis, and we don't have an earthquake code." The architect, HOK, suggested that the owner should design the project for earthquakes. And so, we did it. It had a tremendous influence on my career, honestly.

You've had several careers beyond your work with precast, can you talk about a few of them?

Throughout my career, right from the beginning, I did not look at any building as a project. I looked at my work as part of a system. I know that building is a part of this whole complex and it's a part of this entire community.

I have been CEO, President, Partner, Chief Engineer, and Owner of many different consulting firms. I spent most of my career—25 years—in California. In the early 1990s, I was a partner with a firm in San Diego. The city was booming, and our firm was working with a big developer on many of the city's high-rise buildings. As part of my work, I occasionally published articles in the *San Diego Tribune*, so that may be why I got a call from a staff member with a state politician. I was surprised by the call because I didn't contribute to any political parties, so I asked what I could do for him. All he asked was for me to spend 30 minutes with the city's representative in the California legislature because "We read that you have a lot of experience in changing things around for different companies." Pete Wilson, the new governor, wanted to change the way the Division of State Architect operated. That office controlled the design and construction of all schools, community colleges, and hospitals in the state. The State Architect was appointed by the governor, but the Chief of Operations was a civil service position. They wanted someone from the private industry to take that role. So, suddenly, I was in the government. I had no idea how the government works, and that's exactly what they wanted. The department had offices in San Diego, Sacramento, Los Angeles, and San Francisco, each with about 280 staff members: architects, structural engineers, fire and life safety engineers, and others. The annual budget was about $4 billion, with responsibility for over 4000 projects. The state had 1008 school districts and 107 community college districts, so it was a humongous challenge because every school and community college hospital had to be certified by the Office of the State Architect for a high level of seismic resistance. Of course, coming from private industry, I heard a lot of "But this is not how we do it...we are a government agency." Our office charged a fee for reviewing documents. To make a long story short, I started meeting with those in charge of the various offices, and I told them that we had to reduce the review time and work within our fees. When I met resistance, I informed them that I was the captain of the ship, and I was changing our heading. We created different channels for reviewing projects, depending on the building type, and so we reduced our backlog and reduced our review time from 6 to 10 years down to 3 years.

When a new governor came into office, I left and took a position with the National Science Foundation. They had heard of my work in California, and they wanted me to come to Washington, DC. I didn't need the job, but they made me a good offer and so I took a 3-year appointment as Director, Engineering Research Centers Program. In that role, I manage three seismic research centers: Berkeley, Illinois, and SUNY Buffalo. Again, I looked at the centers as part of a system, so along with engineers and geologists, we brought social science and economics into the decision-making process. I left that position after two terms (a total of 6 years), and now I'm involved as a consultant to research centers, as an invited lecturer on how we can create resilience and use risk analysis in our decision-making processes, and as a part-time full professor at three universities. I am a Distinguished Senior Fellow of the Global Resilience Institute, Northeastern University, a Professor of Practice at Iowa State University, and an Adjunct Professor, Civil and Environmental Engineering, Notre Dame University. I've learned that I must keep learning constantly. That's what I do...I'm just a curious person by nature.