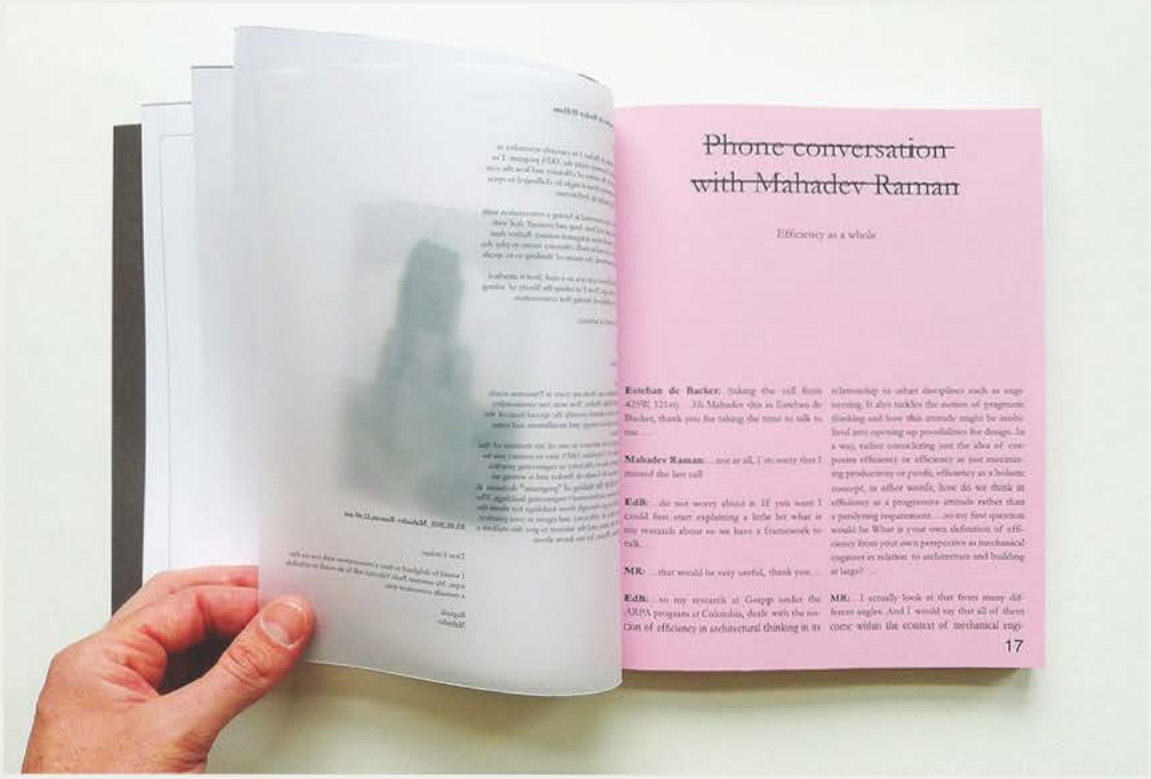
EFFICIENCY AS INTEGRATION

A conversation with Mahadev Raman

Triple bottom line.

Published July 3, 2015



The Un-expected_An architecture of Efficiency. Image courtesy of Estban de Backer.

This interview is the second in a series of interviews conducted by Esteban de Backer to question the status quo of efficiency in architecture.

Mahadev Raman is a Director of Arup Group Limited, the Chairman of Arup Americas and an Arup Fellow. He is a mechanical engineer by profession and has been in practice for 35 years, providing engineering design leadership for multi-disciplinary teams on a wide variety of projects globally. He has particular expertise in the design of sustainable, high-performance and energy efficient buildings and has pioneered the use of sophisticated analytical techniques to improve the performance of low-energy designs.

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ESTEBAN DE BACKER [taking the call from 425W, 121st:] Hi Mahadev. This is Esteban de Backer. Thank you for taking the time to talk to me—

MAHADEV RAMAN: —not at all. I´m sorry I missed the last call.

EdB: Don't worry about it. If you'd like, I could first start by explaining what my research is about, so we have a framework to talk—

MR: —that would be very useful, thank you.

EdB: My research deals with the notion of efficiency in architectural thinking as well as in other disciplines such as engineering. It asks how pragmatism might be mobilized to open up possibilities for design. Rather than only consider efficiency in the corporate sense—to maximize productivity or profit—how can we think of it as a progressive attitude, and not a paralyzing requirement? As a mechanical engineer, how do you define efficiency in architecture and buildings at large?

MR: I look at this question from many different angles—all within the context of mechanical engineering. One aspect of it is performance efficiency, which is mostly measured in terms of energy consumption. So, to keep the inside of a building comfortable for human beings, particularly in a climate like New York's, you need to provide heating in the winter, cooling in the summer, and ventilation for fresh air. All of these functions require energy. You can see significant variations in the amount of energy that different buildings consume in order to provide comfort for their occupants. Energy consumption is therefore one measure of efficiency.

Energy consumption is not just a function of the mechanical system itself. The mechanical system also responds to heat exchanges at the façade. How well is the façade insulated? How well does it thermally separate the inside and outside environments? How does it provide shading, while also admitting daylight? All of these factors influence energy efficiency. Similarly, the quality of the electric lighting system, in terms of the efficiency of the fixtures, also impacts energy consumption. How much heat do they add to achieve the desired level of light? In this way, other elements of the building start to have an impact on the efficiency of the mechanical system. Even if you are measuring the performance of the mechanical system, the outcome is highly reliant on other disciplines.

Another measure of efficiency is how quickly a project can it be built. In the American commercial property market, the approach to mechanical engineering in office buildings has been refined and standardized over a long period of time. What that standardization allows you to do is have one meeting right at the start of the project with the architect, the structural engineer and the mechanical engineer. The three of them can then go their separate ways to document their designs. That way when they come back together, everything fits together perfectly! Of course, I'm exaggerating to make a point. By following tried-and-tested methods, the process is very efficient in terms of time. However, it doesn´t necessarily "stretch" any of them outside their comfort zone!

Shortcuts in calculations are another aspect of efficiency. While this might save design time, it usually results in the over-sizing of equipment. Let me give you an example from the old World Trade Center. I remember being on a tour of the Twin Towers, where we were shown the big cooling equipment in the basement. If I recall correctly, there was something like eight big water chillers that provided chilled water for the cooling of the building. While I was walking around, the operating engineer remarked that they never needed to run more than five of these machines in order to cool the entire building! So, there was clearly a lack of efficiency with regard to the use of resources. They bought three additional machines that they didn't really need, probably at a cost of millions of dollars.

EdB: Even if these standardized means are efficient per se, the end result is not efficient at all. There is a paradox here.

MR: I suspect that the engineer had a very efficient process. While he could quickly calculate the size and cost of these machines, a more accurate analysis would have to be more sophisticated and repeated several times as the façade design evolved. There is an efficiency of effort up front, which often results in a lack of efficiency in terms of the system and the use of material. The paradox is that these two things work against each other.

EdB: In your 30-year career, with projects ranging from Richard Roger's Lloyd's of London Building to Simons Hall by Steven Holl, how have you seen the concept of efficiency evolve over time? Historically, in relationship to different energy crises, rising environmental consciousness, and changes in user behavior, how has the measurement of

efficiency changed over time?

MR: There was a time when initial cost was the main factor people looked at. Sometimes time would play an important role, but cost was always the dominant consideration. So, if one team could deliver a project for "x" dollars per square feet, and another team could deliver it for less, their output was considered to be more efficient. During the energy crisis in the mid-70s, operating cost also became an issue, even though I would say that the thrust towards increased energy efficiency was driven more by more stringent building codes than by a market response from the industry itself. City administrations changed the code to insist that buildings become more efficient. Just by following the requirements of the code, you could develop a more efficient building than you could in the past. But even then, the ultimate measure remained cost.

In the modern era of sustainability, there are rating systems like LEED, which have introduced many other dimensions beyond energy, such as water use, air quality, and so on. At this point, getting an absolute measure of efficiency is difficult—some of these factors are qualitative, and cannot be compared to each other on an apples-to-apples basis.

There are other factors that can drive building performance. For example, I have heard about a scheme in San Francisco whereby a developer who agrees to do a LEED rated building can get expedited planning approval. This is a factor that influences behavior, but it is not really based on performance efficiency in the strict sense. If I can get my approval faster, I can build it faster, and I can start to make money faster.

EdB: Somehow everything boils down to the question of quantitative versus qualitative values, in which the quantitative presumes to foresee and control the future—the one that the market advocates for.

MR: Qualitative considerations may drive you towards something that is not perfectly efficient in terms of energy, but that is overall better in terms of, say, LEED rating. This transformation in thinking—the more holistic view of sustainability—started to take hold in the mid-nineties. In today's more embedded approach, the performance of any facility has to meet a certain benchmark, which automatically draws with it a degree of efficiency. People are trying to deliver better buildings, but usually at the same inflation-adjusted cost that they might have incurred historically! There are many alternative design solutions that can meet any set of requirements.

EdB: You have advocated for the reduction of mechanical systems to their minimum necessity, and for the idea that energy should be addressed at the very beginning of the design process. Could you expand a bit on the notion of efficiency as a holistic consideration, that is, as a strategy rather than an afterthought?

MR: I think of it as a two-pronged process. One aspect is what we might call "prevention," and the other the "cure." Prevention shapes the building—its façade design, its materials, its orientation and its surrounding landscape, among other qualities—in such a way to minimize the extent of mechanical systems needed to make the place comfortable. Some climates are more suitable for this than others. In Santa Barbara, California, the climate is so benign that you would have to really screw up your building to need any mechanical systems at all! Still, the prevention side is certainly something you can do anywhere. In climates like New York's, it's still possible to minimize the size of mechanical equipment even if you can't eliminate it completely. The prevention dimension is very important, and I think it's where we have to start in design. It is interesting to note that most of the elements optimized as part of prevention are not designed by mechanical engineers at all—they are designed by the architect, the interior designer, the lighting designer and the façade engineer, among others. To get the most out of the prevention approach, you need to have like-minded people who are open to collaboration, and to the influence of a mechanical engineering agenda on their designs.

The second part of the process is the cure. Once you have developed the best possible building, you have to deliver its remaining needs in the most efficient way possible via mechanical systems. There are many possible approaches to this. To give you one example, you could use an all air system, like a VAV [Variable Air Volume], in which all heating and cooling is provided using air. What developers like about this system is that if

you want to make any modifications after you install it, you can just cut a hole in the duct while the system is running, or connect it to another duct for a different arrangement of outlets. You don't need to shut anything down, you don't need to drain anything and there's nothing that can spring a leak. While it has a lot of practical benefits, it uses much more energy than an air-water system, which uses air for ventilation, and water to deliver energy for heating and cooling. Water is much more efficient at moving energy from one place to another. But the problem with an air-water system is that now you have a system that could leak, a system that when you want to expand or modify it, needs to be shut down, drained and all of that. That said, your system will use much less energy. Those are some of the dynamics that you end up with.

Other considerations on the cure side include deciding what the energy sources are going to be. Are you going to burn natural gas and have a boiler supply your heating, or are you going to go for a geothermal system? All of the mechanical decisions lie on the cure side of the equation, while all the passive measures designed in collaboration with other disciplines rest on the prevention side.

EdB: What do you think is the trend in collaboration with architects? Does it happen more on the side of prevention or cure?

MR: I think both are quite strong. Architects are becoming more knowledgeable about prevention. Let me give you an example. You mentioned the Lloyds building, right? This is a building that I worked on in 1978. The energy crisis had just happened and there was a big move to conserve energy. The design team—the architects at Richard Rogers and Arup—agreed with the client that we would try to do an energy efficient building. That was the goal, and I was the young engineer who knew how to run the computer program to calculate energy consumption. The problem was that the predicted energy consumption was crazy high. Why? Just look at that building. Look at the surface area exposed on the outside. The stair towers, toilet modules and ventilation ductwork all have multiple surfaces exposed to the external environment. Each toilet module has five exposed surfaces to the outside. Each stair is a spiral, so every wall of the stair is exposed to the outside. There is so much exposure that even with a good level of insulation, the building still consumes a lot of energy for heating. I don´t think architects of that era even considered the impact of exposed surface area, whereas today, architects have a greater level of awareness of these issues starting from their education.

EdB: Somehow, it seems like efficiency was the means but not the end, or the goal, of the building.

MR: No, one of the goals of the building was certainly energy efficiency, but the architectural expression worked at cross-purposes with that goal. And it´s not because the architects were bad, in fact they were very talented and dedicated. They just hadn´t internalized the impact of the factors that they had control over—factors that could seriously affect the efficiency of the building. It still ended up being an efficient building by the standards of that day. But by today's standards, it´s an energy hog.

Since then various things have changed. At that time, energy codes hadn´t been written yet. Education also helped shape what designers aspire to achieve with regard to performance and efficiency. But I would say the collaborative process has not changed. The idea that you get a better outcome by collaborating with all participants at the earliest possible stage in the design has been understood for quite some time.

EdB: But it probably doesn't happen frequently. I come from Europe, from Spain, and I see the collaboration with engineers starting after the building has been designed, as an afterthought rather than, as you were suggesting, a preventive measure.

MR: That happens everywhere, and not just in Spain. It depends entirely on how enlightened an architectural practice is. So if I may characterize it this way: at one end of the spectrum you have an architect who will do a design and leave it to the engineer to make it as good as it can be, in terms of performance, without impacting the architecture. On the other end, you have an architect that challenges the engineer on day one to come up with creative suggestions that simultaneously contribute to the design and enhance performance. I have worked with architects in both camps, and it's no mystery which approach I prefer!

EdB: I believe there is a creative opportunity in this kind of collaboration. Unexpected solutions might emerge from this way of thinking about architecture. So my question is about the role you think creativity plays in collaboration. Are there any buildings that exemplify fruitful collaboration?

MR: I can't put my finger on any single "best" building, but I can give you some examples. Even going back to the Lloyds building, despite what I just said about surface exposure, if you look at the details you'll see that a lot of effort went into designing components like the ventilated façade, which performed very well. A very clever structure was designed to maximize thermal mass accessible to the space in order to partially control the internal environment. And there were well-integrated light fixtures and ductwork systems. There was a lot of very close collaboration and integration. What is interesting about the High Tech style in architecture, which was in vogue at that time and practiced by architects like Richard Rogers, is the desire to leverage the engineering components of the building to further an aesthetic agenda. So, anything that we engineers designed, like ductwork, structural supports and light fixtures, became material that the architects could co-opt into their design expression. That tradition never took hold in America—the expression of a building rarely draws from the engineer's palette, particularly the mechanical engineer's. That doesn´t mean one approach or the other produces better buildings. Both are capable of delivering high performers and lemons!.

EdB: From both perspectives you can design a good building, with inventive solutions.

MR: Yes. At the bad end of the High Tech side, engineering is used to create expression in such a way that the engineering components themselves are actually inefficient. You see that happening in cases where all the supports are arranged in fancy ways for purely visual reasons—when in fact, there are much more efficient ways of achieving the same structural goals.

EdB: That relates to my comment about efficiency as a means rather than as an end. Sometimes design focuses on the way something seems to perform, rather than the big picture.

MR: This is when some dishonesty comes into the process. In other words, an architect puts gratuitous engineering elements in place to serve an architectural agenda, rather than adopting the necessary engineering elements to further their ideas. Those are two very different attitudes.

EdB: It should be understood as an attitude rather than an aesthetic agenda.

MR: Yes, exactly. It is an attitude. If an architect says, "Okay, Mr. Engineer, what is absolutely needed in this building? How can I use that to further my architectural goals?" I would call this the honest approach that would lead to a more efficient outcome. Whereas if he or she says, "Okay, Mr. Engineer, I would like to see a cable structure over here because I think it will look nice. Try to make it work!" —that is a very different conversation.

EdB: Sure. This makes me think of the new Congress Center by Herreros Arquitectos in Bogotá, Colombia. He used three-meter high trusses to allow air to circulate through the floor without mechanical systems. They designed with an understanding of engineering systems, and with an aesthetic agenda to be sure, but in a very progressive and productive manner.

MR: That makes sense. It seems that this had a healthy kind of collaboration. Considering a building that does not overtly express its engineering, but functions very well—one of my favorites is Richard Meier's Jubilee Church in Rome. Do you know that building? It has three concrete shells that are symbolic of the trinity. The thermal mass of the shells, the skylights in the roof and the undercroft space over the foundations all work together to control the temperature and ventilation within that building. If you walk in on a hot day, you will feel comfortable. All of these materials are connected in a way that controls the environment for you. While there is no expression of the engineering, it is subtly evident in your experience of the space.

I would draw a distinction between the leveraging of technology and engineering for an

architectural agenda, and truly efficient engineering design. The two don't necessarily go together. The fact that you see a lot of technical expression in a particular piece of architecture doesn't necessarily mean that it is efficient. And just because you don´t see the expression of the technology in the building does not mean that it is inefficient.

EdB: As a final question, what do you think is the right question to pose in the future regarding efficiency in the built environment?

MR: That´s a difficult one—it's hard to hone in on a precise answer. But I would say that one useful concept is the triple bottom line. The triple bottom line says that for a particular project to be considered efficient you have to find an optimum balance among three factors. The first is the social dimension: how well does a building fulfill its social purpose? The second dimension is environmental: how well does it conserve environmental resources in its construction and operation? And the third dimension is economic: how affordable is it in terms of both the initial and operating costs? I´ve also heard the triple bottom line described as a balanced consideration of people, planet and profit..

So, if you have a great project that maximizes social benefit, has a low cost and is great for the environment, you are extremely fortunate! Go build it. It will be great! But usually, there are difficult compromises that have to be made. The important thing is to be conscious of each of these dimensions and give it due consideration. By contrast, I would say that any building that ignores any one of these dimensions is definitely flawed and inefficient.