Invited Lecture: Patricia Galloway
-Sustainability Considerations for Design-

Today I wish to discuss with you sustainability considerations for design; something that all of us engineers, with respect to out code of ethics for the American Society of Civil Engineers and the Japan Society of Civil Engineers and other engineering organizations around the world that we are fortunate to have with us today, tell us that sustainability is now a requirement in anything that we do relative to design.

So what is sustainability? Well, it is the practice of adequately meeting current needs while ensuring that future needs will be adequately addressed. It is ensuring that all of the worlds inhabitants - from those living in the most developed nations to those living in the most underdeveloped nations – are ensured food, shelter and sanitation – both now and in the future. Sustainable design is becoming the expected standard, not just a "green thought".

So what are the challenges to sustainability? Well, population growth is a major consideration in everything that we do as engineers. The population is expanding at a rate of between 80-100 million people a year. The needs in different nations are vastly different from one another, and what we do in Japan cannot be applied to somewhere else in the world. What we do in the United States cannot be applied to somewhere else in the world. And we must understand what those differences are.

The challenge then is to understand what those differences are while we plan our infrastructure projects while at the same time adhering to the sustainability principles.

Well, let us look at developed nations. What are the challenges for developed nations? Urbanization is the greatest challenge. Why? Because we have an aging infrastructure in our developed nations. And when the infrastructure was designed and built at the time there was little consideration given for sustainability concepts and what the impacts would be on the future. The design considerations that we must give today include mitigating air pollution – we must take the carbon out of the air if we are truly going to survive as humans on this planet. We must provide clean water. Water is becoming a commodity that may very well be as precious as gold. We must transport by other means than gas consuming vehicles. And must assure that we definitely have a quality of life that we have been used to. Green building design though requires additional education. Most engineers do not understand what the standards are for green building design. They don't what the conformance means to these new standards. And standards are different within each of the developed nations. They must understand that it will now require collaboration with multiple stakeholders in finalizing the design for green buildings. So the challenge for developing nations, unlike the developed nations, is to improve infrastructure that is going to support a rapidly growing population. Developing nations must apply the lessons learned from the engineering and construction projects in the urban areas of the past, and must review these lesson learned carefully in order not to repeat the mistakes of the past of the developed nations. In underdeveloped nations actually the infrastructure needs are quite basic. The infrastructure needs of an underdeveloped nation are to basically meet the essential needs of human life – how to provide food, how to provide drinking water, how to provide sanitation. Engineers must establish the ability to transport agricultural products to the market. Engineers must have the ability to construct safe and reliable water and sanitation systems. And the mechanisms to get there are usually quite different than they are in the developing or developed nation.

And thus the basic questions to be asked by the engineer include, is the current population able to use and maintain the technologies to be employed on a project? Does the population have the ability to deal with the required computer and other hardware upgrades that must be performed? We must recognized that as a developed nation or developing nations that we might employ the greatest technologies available, and believe that we can build systems and we can build buildings and we can build manufacturing plants in underdeveloped countries, all believing it will actually improve the quality of life, when actually it may degrade, because once it is required to be operated and maintained, the current population will not have the tools, the techniques, or the education in order to do so. So the fundamental concepts to sustainability include environmental protection, economic growth, and social equity. There is something called the Triple Bottom Line, a concept developed by UK engineer John Elkington, that requires a balanced approach to economic development, environmental protection, and social wellbeing. Those economic considerations, what are the questions we as engineers ought to be asking? 1) What is the project cost that represents the best values from the perspective of achieving the project objectives? Have the life cycle costs been analyzed to determine the total costs of project delivery over its expected life. Just because a project costs less today to construct, does not mean that the project may not cost more in the future to maintain and operate than a higher cost construction project today. It is our responsibility to inform our clients what the total cost of the project will be over its expected design life. Have the environmental factors been included in the evaluation of those assets and services because it is an absolute top priority as we face the global crisis today. How does the project interact with the natural environment? Is it pleasing? Have the social management aspects been considered? Do we strike an imbalance with the environment by building something that is not natural to the environment? Are there any concerns relative to the materials or the products which are proposed which could have future negative impacts on the project depending on the use and application of the particular project? We must recognize that applications of projects today may actually change in the future. We must recognize that certain power plants of today are actually being converted to different types of fuel for power plants of the future. What are those implications of the new considerations versus the old?

The social impacts – we as engineers often take little consideration of what the person next door thinks about what we are building. But we should be asking the question, how will our next door neighbors view this project? How will they be able to best use it? And we should be seeking their input and guidance as to how this will best serve their needs, because we as engineers have the social responsibility to protect the public health, safety and welfare. How can the project be best integrated into the community, because it is the community as a whole that will need to derive the benefits of any project we design and construct. Will the health, diversity and values of the community be maintained with this project? Will they be enhanced for the benefit of future generations? Is the life expectancy of selected materials for products the same relative to the social expectation of how long that project will function as designed? There is a typical thought that a public project should be designed for a minimum of 50 to 100 years. Why is that? It all comes down to taxes and funding? We are very much aware of what we can and cannot afford to design and construct for public moneys. We must be aware that what we design and construct today must last well beyond our lifetime, and potentially well beyond the next generation's lifetime. Is there a need for future inspections of any aspect of the project regarding its structural integrity to assure its sustainability over the expected design life? We designed it for 100 years; therefore it must be going to last for 100 years. Yet we have no idea what the environmental impacts will be for that project. We have no idea what the human element of impact will be to that project. We have no idea sometimes with new technologies and new products and new materials whether or not they actually will perform to the design life as theoretically designed, and thus it is important to provide the necessary inspections to insure that in fact the project that we have designed and constructed is going to survive over the expected design life at the time of inception. And thus becomes the need for asset management. Asset management is a systematic process used to maintain, upgrade and operate physical assets cost effectively. It is something that governments and communities are now asking for the engineer to recognize that it is an asset of the public and the community, and that asset must be maintained and operated as would any of the typical assets that we think about as being physical for which we find value. Increasingly cities and governments are looking toward adapting asset management as a practice which will be common and all engineers must understand what that means. And while the need for the method of asset management has in the past been constrained by budgetary consideration, it now stands as a top priority. Asset management is concerned with improving the durability of structures, reducing the need for maintenance, repair, strengthening or replacement. The management of structures thus becomes more cost effective when we look in the whole life terms, and not just looking at what we do today. Structures last longer with asset management while at the same time meeting the safety and functional requirements. A key tenet of asset management is a process of early intervention taken before project failure that minimizes the cost stream. Projects will deteriorate over time, and thus as I indicated inspections are necessary, maintenance is necessary, operability considerations. They are all critical tasks that should be considered in any infrastructure design being constructed today. Asset management calls for a comprehensive assessment of all costs – design, construction, operations, maintenance – again, the entire life cycle cost analysis. So our goal – what is our goal? Well, the Order of the Engineer, which I talked about many times, with the steel ring that I wear proudly upon my working hand, our professional society code of ethics, our licensing boards in states in the United States, your licensing board in Japan, licensing boards in other countries, they actually define very well our role and responsibility. Yet when I ask engineers how recently they have read their code of ethics, whether or not they have even read the law of their country or state with respect to their licensing responsibility, very few engineers can answer my question that they have. Yet it is the very ethical, moral and mandatory responsibilities that we have, and yet we don't take the time to recognize what those are, and if we fail to do so what the consequences are, not only to ourselves, but to the public which we serve. The role is to design a project which meets its desired purpose. That it is constructible. Often engineers pay little attention to the constructability aspects of their design, especially in the wake of new emerging technologies. They seldom collaborate with the stakeholders of those who will actually be building the project to determine weather or not there actually will be risks in how that project is to be constructed. We need to ensure that in that design and in that construction that the public's health, safety and welfare are protected. Today are goal and responsibility goes beyond protecting the health, safety and welfare of the public. It now goes to protection of the environment as well. And it is the protection of that future generation and environment that makes us in the crises that we are in today relative to how little we actually know, yet how much is expected of us to solve the crises that I talked about in the opening address. Public works projects, again, are constructed for the public welfare, and thus we do need to give consideration as to the projects long term impact to society, and pay attention to the ultimate client objective, that play a very important part in the design. An example of pipe, since we are talking a lot about water resources today and how water is conveyed from point A to point B, and it is essential for any drainage, or sewage, or for transporting portable water to people, yet the types of pipe products available to us are enormous today. We have gone well beyond just the concrete type of pipe. We now have corrugated metal pipe. We now have plastic flexible pipe. We have ductile iron pipe. We have many types of ways of conveying that water. Yet regardless of the complexity, the decision of the engineer regarding the pipe product selection can have a major impact on the performance of sustainability of the project over its expected design life. And why is that? Because frankly, it is no longer a material substitute. Very few products today are actually quote "material substitutes". The clients may look at the products as material substitutes, but remember our clients are seldom engineers. Our clients don't have the knowledge relative to the use for the application of various products and how they will last over different life spans and under different conditions. We as engineers often choose products due to our clients requests, or due to a misconception that an "or-equal" clause is applicable no matter what is selected. But partial facts can lead to very dangerous risks. The price may lead to a false impression that because for instance in a pipe selection, because the initial material may be significantly less than another product selection. That for some reason the product and the project will cost less. But this is not the case, and making any such assumption adds an unnecessary risk to the project. In today's projects, where sustainability must be taken into consideration, as required again by our code of ethics and our professional engineering practice pacts, engineers cannot ignore that a client's request may actually not be appropriate, or it may not be in accordance with the overall engineering practice to which we are bound, and thus we a put in the dilemma. But what dilemma is that? Is it really a dilemma or is actually part of our role and responsibility, to look at lifecycle costs, to look at asset management, to look at how our different selections have an impact on those very topics, and how we convey that information to our clients. That is our responsibility, to assure that anything we design is going to protect the public health, safety and welfare, and the environment of today. So we must know the differences between products. We must determine who the manufacturers are, and we must understand as engineers that we must decipher the hype of advertising in product brochures versus the more detailed information from that manufacturer relative to how that product will perform. We must recognize that different products may require different requirements, and take into considerations different elements that we may not have thought of. We must understand that there may be different standards for which we must recognize in our design. For instance – pipe – there are different standards for ASTM and AASHTO in the United States relative to plastic pipe, concrete pipe, metal pipe, and ductile pipe. And it is our responsibility as an engineer to understand what those different standards are, and how that affects our design. We must recognize that the installation of some products, such as a flexible pipe is an engineered installation, and that we have to take an active role in the inspection of that in the field, and cannot walk away once we believe our design has been completed, because in all instances it has in fact not been completed until it is installed in the field. And thus the reason for inspection post completion, and the reason for lifecycle costs and risks. So lifecycle costing, it is an integral part of the design process. While particular products, as I mentioned, may be less initially, the inspection, construction, and operations and maintenance that need to be performed post construction have to also be applied in that consideration, and must recognize that they can have different results. Inspection has always been a critical component of asset management, and the longevity, depending on the application, could be a consideration which impacts future repair or replacement costs. If we don't do the proper design, and if the constructor does not do the proper installation, failures could result, which in turn could result in property damage, and again, it is our role and responsibility to protect both the public and the environment. For example, relative to pipe selection there have been numerous examples the world over relative to either pipe flooding out of the ground, roadways and drainage systems failing, and not because the product may not have been a good product, but because we as engineers may have selected the wrong product for the wrong application. And so if these events occur there are far greater consequences on our communities, and thus the social impact becomes a condition in the design process. In today's environment the client is not looking only to us to provide solutions of what may be in the best interests of our communities today, but that will serve as a guide and a service for tomorrow and the future. Sustainability considerations, lifecycle costing, asset management, are all areas that we must address, along with the risks that arise, based on decisions that are in these considerations, which in turn may fail to meet a standard care if we don't do and follow the knowledge that we know is in front of us. The design process must consider the knowledge of particular product performance, and that we must assure that we have recorded all of our assumptions in the design process, again, to assure that we have meet our standard care.

So in conclusion, engineers need to look at not only what is best for today, but what is best for tomorrow, what is best for the future. We must recognize that sustainability considerations, lifecycle costing, asset management – areas where engineers have had little or no training in their educational systems, or in the practice within their very own firms or governments, yet now are expectations of us, along with risk identification and risk management of all the factors that could arise, not only during our design, not only during construction, but post construction over the entire life of a particular project. Governments must be more active in this consideration as well. Why, because they serve as the base for our public works projects. Governments must recognize and take a major role if true sustainability of our infrastructure project is to be achieved. Governments are going to have to look at different ways of doing business. They are going to have to recognize that with aging populations, and with younger generations not populating as in the past, that the tax base which provides the funds for those very infrastructure projects is decreasing, yet the needs for aging infrastructure, the needs for future projects, is increasing. And how do governments strike that balance of offering different project delivery systems in order to fulfill society's needs of today and tomorrow. One of the biggest challenges to sustainability in a sustainable society is the change needed as our roles as citizens and in government relative to the transition to a sustainable society includes providing information that can inform the publics discussion regarding decisions for the future. We have a duty to be able to now communicate, not just in writing, but orally. We have a duty to lead our world and our citizens in solving these global needs and crisis of today. We have a need to understand how the societal impacts may affect our design, and thus we must understand how to integrate that into our design and construction. We must develop sustainable consciousness, something that a lot of the older generation has not been used to doing, but something that the newer generation is demanding. And we must play a major role in this regard. In that way we must understand what the concepts of sustainability mean. We must recognize that our role has been heightened, not only to protect the public health, safety and welfare, but that of the environment as well. Economic, environmental, and social perspectives are now all key elements facing the twenty-first century engineer. We must face new challenges, and we must do so in delivering the best practices to our clients, which will require new concepts, new knowledge, new information, and new understanding that we have never had before. We have big challenges ahead of us. And I hope that the challenges that you will hear throughout the conference today will provide you more information relative to all of these items which I have present here, and you will be able to take home the tools to add to you own toolkit on how to do lifecycle costing, asset management, and risk management.

What is really fascinating to me…over two decades ago requiring engineers to take into consideration sustainability. In fact it was really quite interesting, I remember it very well, because there was a debate and a battle within civil engineers, as to not only what the definition of sustainability meant, but why they had to include it in a code of ethics? One saying well of course we would do that. Others saying that is not our responsibility. And others saying we have to define it because it is our responsibility. But yet when I ask engineers in the United States today, have you read your code of ethics – no. They don't even know that there is a sustainability consideration in their code of ethics that was put in there two decades ago. You are beginning to see engineering practices acts changed in the United States within state governments, that are changing what is called administrative of law, that explains what an engineer is responsible for. And one of the consequences that is arising in the United States, and I alluded to it in my presentation, is engineers are being charged for not having met the standard of care. When projects are going over budget, when projects are going over schedule in times when budgets are extremely tight, when emerging technologies are coming about which may not result in a final outcome as expected, clients are now turning around and actually suing engineers for not having met standard care. And in the past we are all used to errors and omissions insurance for if we actually make an error. But a standard of care has very little to do with a design error or omission. If you look at most contracts, in most international contracts engineers seldom see the…the sentence that is in an article in almost all international contracts today that says, an engineer will perform to the highest standards, or an engineer will perform to a standard care. That has now been defined as performing as a reasonable engineer would have done in the same situation, in the same locale, under the same conditions. It takes you beyond your contract as to what you should have known that was foreseeable relative to the knowledge that was available to you to properly design the project. And sustainability is now being considered as one of those things that engineers should know about, and take into consideration in their design. And the failure to do so can be a consequence of being alleged to have not met a standard of care, which if you are found not to have met a standard of care, than you are deemed to have been negligent. And all of these were, some of the gentlemen in the room who have studied law realize that that is a very dire consequence, to be accused of being negligent, yet again, we seldom teach our young engineers, our engineers of today, about any of what I just said. So we have a long way to go in that consideration. But yes, sustainability is actually incorporated within the code of ethics, and actually being incorporated into the professional engineering acts in many of the states in the United States today.