

## Case Study #4: Steel Technology and Big Infrastructure

The understanding of materials and their applications to technology like construction and transportation through the use of good engineering practices is a common thread between Professor Koseki and Professor Salvucci's presentations.

Steel is an alloy composed of iron and carbon. However, it can have other elements as well, including silicon, manganese, and chromium, as Professor Koseki discussed. Processes like the Blast Furnace, the Bessemer Process, and the Thomas Process improved the production process of steel. The fact that steel can be made lighter and lighter while increasing strength is an important part of its usefulness. These material properties give it excellent engineering properties and played a role in its ability to “drive the Industrial Revolution,” according to Professor Koseki. Koseki states that by controlling the microstructure of steel (for example, by heating steel to change the cubic structure from face centered cubic to body centered cubic, etc), the grain size, the capabilities can be widely varied. Microstructures such as pearlite or martensite can be used for various applications—martensite is brittle but strong, and is thus used in knives or swords, while pearlite can form steel wires capable of holding up a bridge, such as the world's longest suspension bridge, the Akashi Kaikyo bridge in Japan. There are 3500 grades of steel used industrially, showing the variety used.

Steel makes up 90% of metallic materials used worldwide. You cannot make a big structure with wood, cement, or titanium, argues Professor Koseki. He argues that “steel is not an old material, but a new material”--by this he means that the improvements to steel, along with its wide variety of uses and applications are continually growing. Steel is used to build ships, automobiles, bridges, buildings, power lines, highways, stadiums, and structures that require strong support. Koseki asserts that many people do not realize the significance or the importance of steel in daily life. The applications of steel are so wide for two reasons: its strength can be varied, and it can be made light. Therefore, you can build things like a 400 meter long ship (60 meters wide, 30 meters tall) from steel. Steel also has many practical applications since 60% of it is recycled, and thus it is a widely renewable resource which is environmentally and economically friendly. Koseki argues that steel's applications range from “life, safety, security, energy, transport, [and the] environment.” Steel is also inexpensive and shows a stable supply. It is formable, machinable, and weldable, making it perfect for a variety of uses. It displays a strength range from 50-5000MPa, it is ductile, and can withstand high and low temperatures and resists corrosion.

The most common uses of steel include building ships, automobiles, trains, buildings, power lines, highways, bridges, etc. However, it also has many other applications. Since stainless steel doesn't rust, it is very beneficial to use in corrosive environments, such as the petroleum industry, the chemical industry, the food industry, and desalinization plants. It also has high tolerance of both high and low temperatures (due to its low coefficient of thermal expansion and high melting point), so it can be used for nuclear power plants, steam turbines and incinerators, as well as in superconductor and fusion reactors, MRIs, and cryostats. It is also commonly used in medicine (i.e. in surgical knives, surgical needles, stents, etc.) because it is clean and doesn't harm our bodies.

Professor Koseki's chart of steel production in the world for 1995 and 2006, which quantifies the dramatic increase in steel production in the span of these 10 years, especially in China, India, Brazil, and Russia (which had 343%, 100%, 23%, and 37% increases in production, respectively) shows that steel has become an essential resource around the world. As

is true with any essential resource, steel producers are always looking for ways to improve steel materials technology. It must be developed to increase environmental friendliness of the energy we use, to make for better transportation, and to help us live more sustainably. In fact, as Professor Koseki mentioned in his lecture, approximately 75% of modern steels have been developed in the last 20 years, and 70% of steels currently used for automobiles did not exist 10 years ago. This gives us further insight into the dynamism of the steel industry.

In Boston transportation, structural steel was used for creating tunnels and holding up overpasses. The Boston transportation system requires supporting complex structures – the bridges that were built as a part of the Big Dig project. Structural steel also played huge part in the creation of the Boston T – digging passageways in the ground and supporting the ground above.

The Big Dig project was developed as a response to Boston's tangled streets, which were laid before the increased use of the automobiles. As automobiles became prominent, the congestion in the already limited-capacity city of Boston forced administrators to think outside the box and initiate the Big Dig project.

With the adoption of automobiles, streetcars became associated with poverty and immigrants. This association caused the residents to not take the streetcar and instead use their cars. Also, in the 1940s, oil, cars and autos all boomed as people moved to suburbs and used more cars/oils. This suburbanization led to the widening of the congested streets but this was not a long-term solution. All these factors combined led to the implementation of the Big Dig project.

Both Professor Salvucci and Professor Koseki display an awareness of audience. Koseki focuses on the details of the materials science of the process, catered towards a class of students focused on the materials and their engineering implications. He shows how important it is to understand the science behind a project before considering how to apply it. Professor Salvucci pulls his audience into an intriguing and personal discussion of the history of his topic by getting to know how much his audience knows about the topic and gauging their background before tailoring his speech to addressing their positions. Koseki clearly explains the materials property basics so that the audience—college students—can understand the science behind his conclusions. Salvucci builds up his talk from a historically oriented view of Boston, making reference to places students will recognize. In my future presentations, I plan to include a good judgment of my audience—a panel of experts, so it will require strong data and well supported conclusions.

Organization and structure is highly important in both speakers' presentations. Koseki gives a brief introduction to the properties of steel and then zooms into each of these properties and explains how specific material structures contribute to the properties that make steel useful. Salvucci presents an in-depth historical overview of the evolution of transportation in Boston, giving his audience a chronological understanding. I hope to incorporate the detailed introduction-analysis structure that Koseki shows in order to help my audience understand the results of our project, and I hope to also provide a historical background like Salvucci does so that the audience can understand the background behind our conclusions.

Salvucci and Koseki use stunning visuals and graphics to present their ideas. Koseki uses technical diagrams and SEM pictures to get across his conception and analyses regarding material structures. He also displays pictures of disasters caused by construction failures to give his audience an idea of what could happen if good engineering practices using steel are not respected. Salvucci shows pictures of Boston before and after it changed at various points. He

clarifies his analyses through the use of images to exhibit the phenomena he describes in Boston at various points (such as horse carriages being used). In my presentation I hope to use such visuals to clarify my arguments and give the audience a clear picture of how the picture fits together and the consequences of not using the materials we suggest, by using useful figures of merit.

Salvucci's main message is carried throughout his speech—regarding the development and changes in Boston and the importance of the role materials science and engineering practices played in the picture. All of his analyses combined the political resolution of social, economic, and technology aspects, and he successfully carried the audience through the successes and failures of each of the transportation industries that were used in Boston. Koseki gives a very detailed overview of steel's materials science properties but continually relates it to its *results* for the applications of steel. He clearly explains his message that we are still in the Iron Age—we are still dependent on the properties of steel—because he continually stresses the improvements we make every year to steel and the new applications we find for it.

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