Graduate	Class Year	Contribution
Horatio G. Wright		Attended in the 1830s. Became Chief Engineer for the Corps.
William Rutherford Mead		Prominent architect who attended for two years and eventually graduated from Amherst College in 1867.

Table 3. Prominent Norwich University engineering graduates in the early years.

A list of prominent Union College graduates and their contributions to America's infrastructure are listed in table 4.

Graduate	Class Year	Contribution
James Chatham Duane,	1844	Chief Army Corps of Engineers
Jacob Hays Linville	1848	Bridge designer and patents
Solomon Deyo	1870	Built the New York Subway System

Table 4. Prominent Union College engineering graduates in the early years.

Civil Engineering Picks Up Steam - The Influence of Government Policy on Creating Land Grant Colleges

As America grew in the second half of the 19th century, the need for more civil engineering graduates, particularly those with expertise in railroad engineering expanded. At the same time federal policy grew favorable towards establishing new colleges during the Civil War. As stated in the Mann Report (Mann, 1918) "During the Civil War Congress passed the Morrill Act (1862) granting federal aid to the several states for founding colleges of agriculture and mechanic arts." The report goes on to summarize the growth of engineering colleges and graduates as shown in Table 5.

Year	Number of Engineering Colleges/Universities	Number of Engineering Graduates
1860	4	
1870	17	100
1871	41	
1872	70	
1880	85	
1917	126*	4300

*Of the 126 colleges in 1917, 46 were land grant colleges.

Table 5. Growth of Engineering Colleges and Graduates (source: Mann, 1918).

Civil Engineering Education near the Turn of the Century

By the end of the 1800s the number of engineering schools had multiplied, largely driven by the formation of Land Grant universities.

The University of Texas at Austin offered four programs in engineering it its 1894-95 catalog including Civil, Sanitary, Electrical, and Mining Engineering and even offered graduate work in Hydraulic and Sanitary Engineering (Malina and Gloyna, 2007).

Prior to 1870	866
1871—1880	2,259
1881—1890	3,837
1891—1900	10,430
1901—1910	21,000
1911—1915	17,000

Table 6. Graduate Engineers in the United States (Mann Report, 1918).

The states themselves also enacted legislation. For example California's 1868 Organic Act led to the creation of the University of California system with the establishment of its first university at Berkeley in 1869 (Rogers, 2002).

Conclusions

As ASCE sits on the cusp of advancing civil engineering education to require a master's or equivalent and recovering some of the credit hours that disappeared in the preparation of engineers over the course of the twentieth century, tracing the roots of American engineering education to the 19th century is helpful. Additionally, by knowing where we have been with respect to education we can understand how our current body of knowledge (BOK) (ASCE, 2008) evolved to where it is today. ASCE is developing a BOK 3 Task Committee to be constituted October 2016 with a publication potentially scheduled for release in fall of 2018, providing a fresh opportunity to explore the depth and breadth of education and experience necessary to practice civil engineering in the 21st century. It is hoped that additional engineering curricula for civil engineering are obtained for presentation at the EWRI Congress in May. Appendix A includes the civil engineering curriculum for Rensselaer Polytechnic shortly after World War 1.

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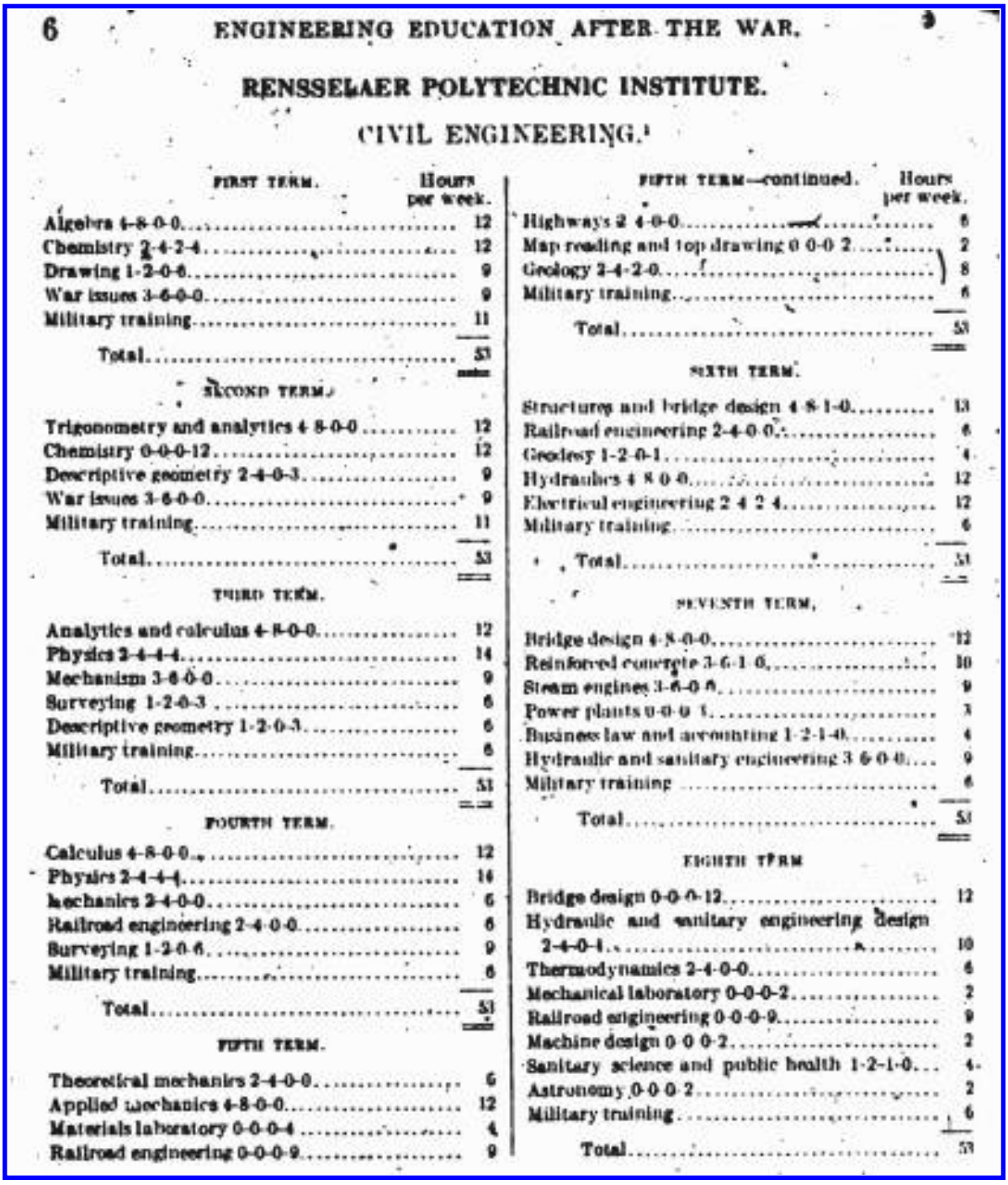
Appendix A

Sample Curriculum Rensselaer Civil Engineering Program after World War 1



6 ENGINEERING EDUCATION AFTER THE WAR.

RENSSELAER POLYTECHNIC INSTITUTE.

CIVIL ENGINEERING.[1]

FIRST TERM.	Hours per week.
Algebra 4-8-0-0	12
Chemistry 2-4-2-4	12
Drawing 1-2-0-6	9
War issues 3-6-0-0	9
Military training	11
Total	53

SECOND TERM.	
Trigonometry and analytics 4-8-0-0	12
Chemistry 0-0-0-12	12
Descriptive geometry 2-4-0-3	9
War issues 3-6-0-0	9
Military training	11
Total	53

THIRD TERM.	
Analytics and calculus 4-8-0-0	12
Physics 2-4-4-4	14
Mechanism 3-6-0-0	9
Surveying 1-2-0-3	6
Descriptive geometry 1-2-0-3	6
Military training	6
Total	53

FOURTH TERM.	
Calculus 4-8-0-0	12
Physics 2-4-4-4	14
Mechanics 2-4-0-0	6
Railroad engineering 2-4-0-0	6
Surveying 1-2-0-6	9
Military training	6
Total	53

FIFTH TERM.	
Theoretical mechanics 2-4-0-0	6
Applied mechanics 4-8-0-0	12
Materials laboratory 0-0-0-4	4
Railroad engineering 0-0-0-9	9
Highways 2-4-0-0	6
Map reading and top drawing 0-0-0-2	2
Geology 2-4-2-0	8
Military training	6
Total	53

SIXTH TERM.	
Structures and bridge design 4-8-1-0	13
Railroad engineering 2-4-0-0	6
Geodesy 1-2-0-1	4
Hydraulics 4-8-0-0	12
Electrical engineering 2-4-2-4	12
Military training	6
Total	53

SEVENTH TERM.	
Bridge design 4-8-0-0	12
Reinforced concrete 3-6-1-0	10
Steam engines 3-6-0-0	9
Power plants 0-0-0-1	3
Business law and accounting 1-2-1-0	4
Hydraulic and sanitary engineering 3-6-0-0	9
Military training	6
Total	53

EIGHTH TERM	
Bridge design 0-0-0-12	12
Hydraulic and sanitary engineering design 2-4-0-4	10
Thermodynamics 2-4-0-0	6
Mechanical laboratory 0-0-0-2	2
Railroad engineering 0-0-0-9	9
Machine design 0-0-0-2	2
Sanitary science and public health 1-2-1-0	4
Astronomy 0-0-0-2	2
Military training	6
Total	53

[1] The numbers given after the courses represent the clock hours in the following order: Recitation, preparation, lecture, laboratory, followed by total number of hours.

Brunel's Launch Ways

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Abstract

Isambard Kingdom Brunel was a builder of bridges, tunnels, steamships, steam locomotives, railways, and gas engines. He was Briton's most famous engineer, and voted second Greatest Briton (after Winston Churchill) in a BBC poll. Like Churchill, he was also the son of an American. When his massive vessel, the *Great Eastern*, was launched in January 1858, she was six times larger than anything else afloat, and sometimes called Leviathan or sea monster. The launch site in London is now recognized as the birthplace of modern shipping and is a Scheduled Ancient Monument, and recently nominated as an International Civil Engineering Landmark. Sadly, this monumental enterprise was also Brunel's last spectacular project, and the ship that killed him.

BRUNEL'S GREAT SHIPS

On the monumental launch ways of the world's most important ship stands a small man with stove pipe hat and cigar. Behind him huge chains, each link twice the size of his head. This is one of the most famous photographs in the world (Figure 1).

Isambard Kingdom Brunel built the biggest ship in the world three times. His first was a paddle steamer SS *Great Western*: the first steamship built for an Atlantic crossing. His second SS *Great Britain* was the first iron ship in the world, towed back to Britain from the south Atlantic and now resting in the dry dock where it was built. His last and greatest ship was the *Great Eastern*, built in London 1858 on the Isle of Dogs. The *Great Eastern* was the biggest ship in the world for half a century, the first bulk carrier and ancestor of the super tanker and container ship. This is the ship that changed forever the patterns of trade and consumption, but also the ship that laid the first three trans-Atlantic cables, and so brought in today's world of telecommunications and information technology. As his friend and business partner Sir Daniel Gooch said:

> *'We have achieved our great object and laid our cable from shore to shore, along which the lightning may now flash messages of peace and goodwill between two kindred nations'.*

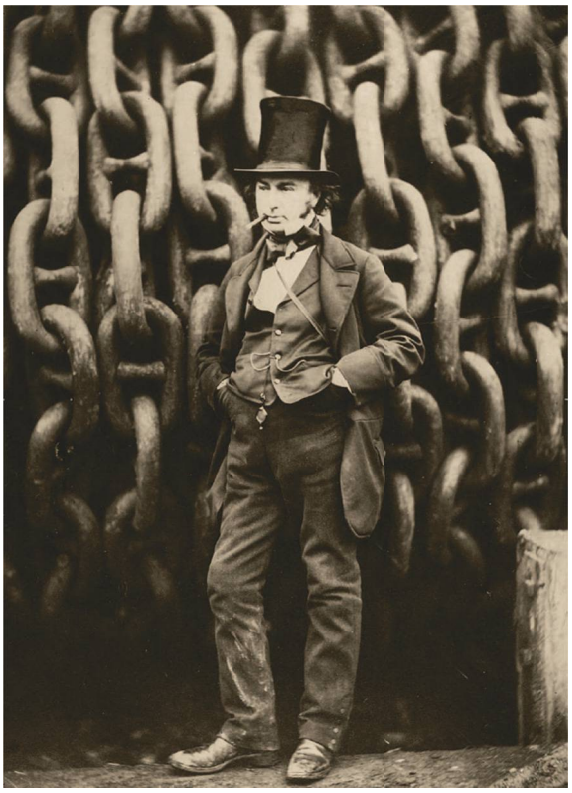

Figure 1. Isambard Kingdom Brunel standing next to launching chains of his ship, the Great Eastern. (Photograph by Robert Howlett East London: 1857).

Figure 2. Building the 'Great Leviathan' by William Parrott (oil: 1854).

THE GREAT EASTERN

The Great Eastern was the world's first bulk carrier, and six times bigger than anything else then afloat. It was launched sideways because the Thames Estuary was not wide enough for a 700 feet long vessel to be launched conventionally, stern-first. Brunel's ship was so big it could steam from England to Australia – and back again – without re-fueling. The biggest ship in the world, and remained so for 50 years: The next ship to pass the *Great Eastern* in size was the Lusitania, the ship whose sinking eventually hastened America to enter the First World War, in 1917. Brunel's ship was nicknamed Leviathan or sea monster. It was also called the floating coal bunker…

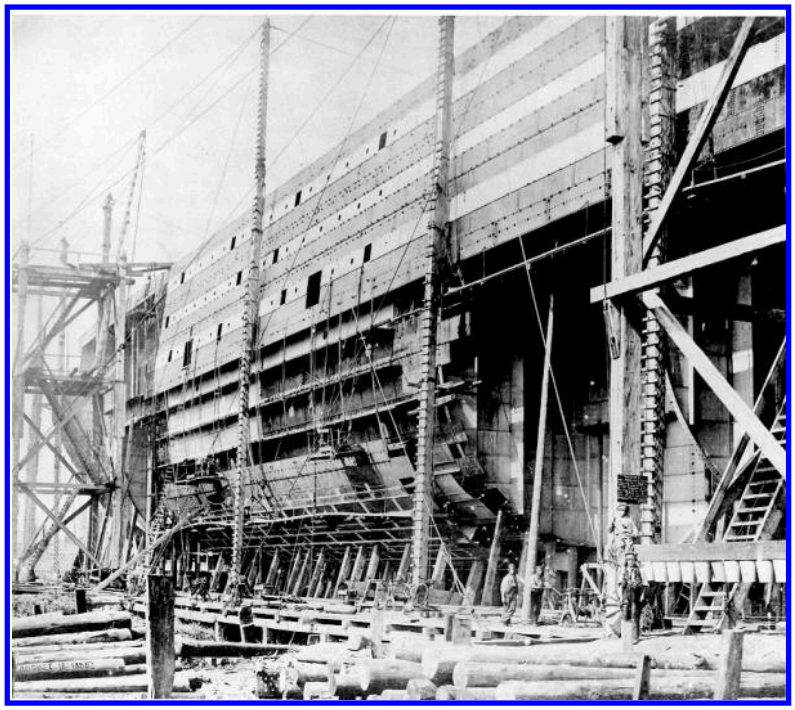

Figure 3. The Leviathan's double hull (Photograph: 1857).

The Great Eastern was the first modern ocean liner, and for three reasons:

i) Double hull, for the first time.

ii) Bulkheads or walls from keel to top deck for the first time.
And these are uninterrupted walls - unlike the Titanic. If the Great Eastern had hit the iceberg, it wouldn't have sunk.

iii) Marine construction on an industrial scale. Thirty thousand plates, each one hammered into the hull with a hundred rivets, so three million rivets - the noise must have

been deafening. Thirty thousand plates, but only three different sizes: we quickly recognize this as standardized production. Today everything is built this way, but in 1858 this was for the first time.

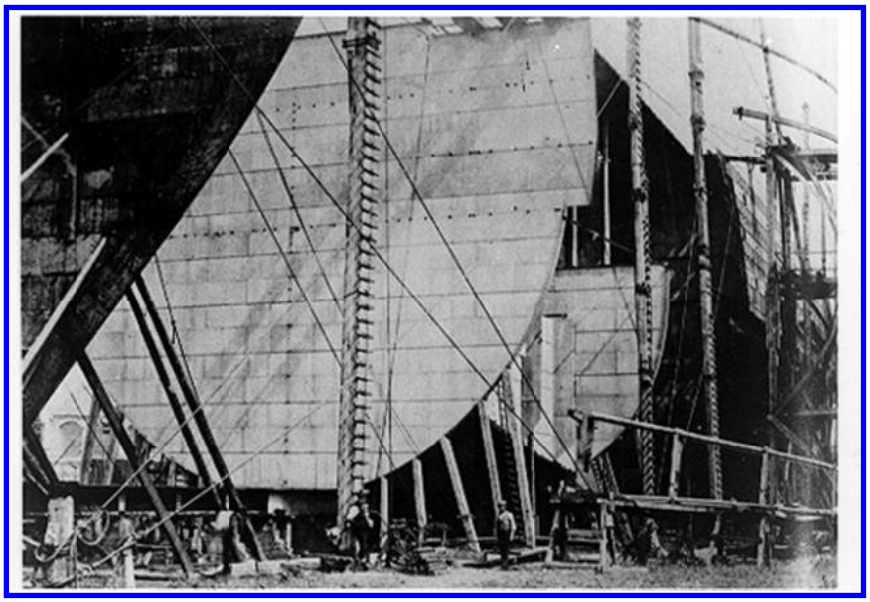

Figure 4. The Leviathan's bulkheads (Photograph: 1857).

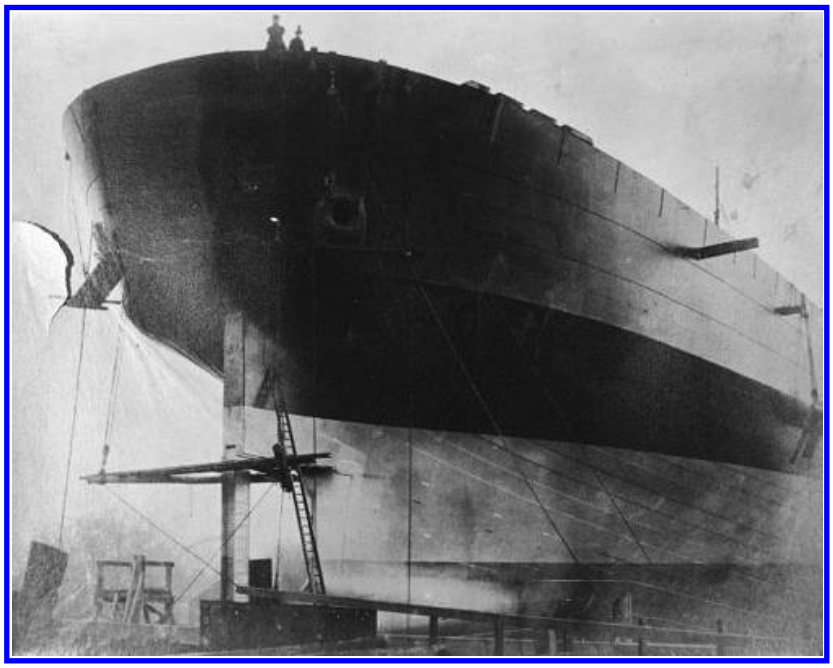

Figure 5. The Leviathan's hull plates (Photograph: 1857).

This was an engineering triumph, the first modern ocean liner, but an unlucky ship. The launch was a fiasco. The famous photograph shows Brunel in front of chains designed to slow the ship on the launch ways, but the ship got stuck. One of the chain drums broke free, and an iron stave cartwheeled across the yard and impaled a labourer. Thousands of tickets were sold for a launch that didn't happen and the crowds nicknamed *Great Eastern* 'the ship that doesn't like the water'.

It was an inauspicious start, but when the ship finally arrived in New York, people lined Manhattan fifty deep to watch the biggest ship in the world steam up the East River. Fifty rows of jaws dropped as the huge ship turned on its own axis: the propellor ship also had paddle wheels, and this gave excellent manoeuvrability. The event of the New York season meant the most riotous party of the season, with spectacular entertainments and circus acts. But while they partied, divers were quietly making repairs: Brunel's ship found Great Eastern Rock as it entered the Hudson. The rock is on the charts now, but it was too deep to bother any ship before the *Great Eastern*.

The truth is, everywhere the *Great Eastern* went, it turned people's heads. A very successful visitor attraction, and Jules Verne, Nathaniel Hawthorne, Henry Melville and others bought tickets just for the experience. The modern equivalent would be 'space tourism'. This was travel in unheard of luxury, and the ship was described as 'four ***** star hotels joined together'

Figure 6. Luxurious public rooms on Great Eastern (Photograph: 1858)

The big ship was perfect for cable laying and laid the first three across the Atlantic.