Heritage Society / Geotechnical Society of Ireland
Joint Lecture

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John Neville
MIEI, MRIA (c1813 – 1889)
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Presentation Outline

• Family & Professional History
• History & Role of County Surveyors
• Roads & Bridges
• Railways & Other Public Works
• Private Architecture Practice
• Technical Publications
• Earth pressures “Investigation of some formulae for finding the maximum amount of resistance behind banks of earth...” Vol 1 Transactions of Institute of Civil Engineers of Ireland 1845
• Summary & Acknowledgements
Family & Professional History

Born in County Limerick 1813.

Education and Training in engineering - little is known. Father (John) was an architect.

Neville worked on Shannon Navigation Athlone 1836 – 1838 performing detailed river surveys at Athlone and worked on locks between Athlone and Meelick. He also gained valuable experience as a road contractor 1838 - 1840.

Appointed as Louth County Surveyor in 1840, resigned in 1886 due to ill health.

Borough Surveyor Drogheda (1852 – 1869) & Dundalk (1863 – 1871)

Engineer-in-Chief Dundalk Harbour Commissioners (1868 – 1875)

Elected MRIA 1844; FRGSI 1845; MICEI 1845; ICEI Council member & vice-president in 1864. Member of the Masonic Order.

Neville was a catholic and in the absence of emancipation in 1829 would have been prevented from taking public office.

Married Constance Percival, C of I, in 1849 in Bruree, Co. Limerick. Family lived in Roden Place and later Jocelyn Street, Dundalk and owned 776 acres in Co. Tipperary.

Two daughters, Barbara and Mary, both became nuns in Sisters of Mercy.

Three sons, William (gynaecologist), Edward (engineer) and John were all raised as C of I.

Died on 10 June 1889 at his eldest son's residence, 71 Lower Baggot Street, Dublin.
History & Role of County Surveyors

In early 19th century, local county responsibility for public works rested with Grand Juries – up to 23 appointed members of landed gentry (1 per barony).

Grand Juries voted on proposals twice each year in private, confirmed by a judge and payments were made on completion from local taxpayers. System was highly prone to corruption, fraud, inefficiency and waste. Individual jurors made proposals for personal gain not in general public interest; payments to landowners made in lieu of rent from tenants; Grand Jury typically had no engineering or construction expertise.

Political reform was first pursued in 1816. In 1817 Westminster Parliament passed a law to allow Lord Lieutenant of Ireland to appoint Surveyors following examination and certification of fitness to hold office.

95 Applicants in 1917 – only 3 deemed competent and none certified!

After further political agitation, a revised bill was finally passed in 1833. In 1834 32 County Surveyors were appointed – none had formal training in engineering (no such courses available in British / Irish universities until 1840s)
History & Role of County Surveyors

John Neville was appointed Louth County Surveyor in 1840 with an annual salary of £400, having taken and initially failed the examination in 1838. Two years spent as a road contractor from 1838 – 1840 was significant in gaining the required experience.

Neville campaigned in 1842 unsuccessfully for modifications to Grand Jury law to allow consolidation of various road maintenance contracts. 272 contracts costing £3,847 per year to maintain 411 miles of county roads. He wanted a minimum contract price of £50 and far fewer contracts, arguing that this would reduce administration costs, increase quality of contractors and attract permanent, experienced workers. County Surveyors would propose and centrally control all road maintenance projects, rather than the Grand Jurors.

Neville campaigned for increased numbers of assistant surveyors with higher qualifications and salaries. Neville had 4 assistants but had found it necessary to personally supplement their salary in order to attract good staff! One assistant regrettably died falling off his horse!

In 1846 Neville published a paper which set out the legal and organisational defects in the County Surveyor system, after it was initially refused by ICEI.

Neville resigned in 1886 due to ill health after 46 years in office – one of the longest serving County Surveyors ever.
Roads

Neville supervised maintenance and construction of an extensive county road system of around 400 miles in 1840. This had increased to 590 miles by 1865. No direct labour – all work was done by contractors.

In 1846 - 1847 Neville temporarily employed 6,400 people on famine relief schemes and he wanted to retain this direct labour system, but was unsympathetic to the employment of women, children and the infirm for social purposes.

He argued to abolish turnpike roads which commonly incurred high staff costs collecting tolls with insufficient monies left over for maintenance. In 1857 full responsibility for 325 miles of turnpike roads in Ireland reverted to Grand Juries.

Irish Road system was the subject of a goods and passenger traffic survey in 1838 by Irish Railway Commission. Goods traffic was centered upon ports, canals, rivers and radiated inland. Drogheda and Dundalk were significant ports. Passenger traffic followed a similar distribution but Dublin to Belfast route through Co. Louth was heavily trafficked.
Roads
Road Traffic
Roads Cross Section,
J. Neville paper published in 1846
Bridges

Neville had a mixed history as a bridge designer.

Aclint Bridge 1842 between Ardee and Carrickmacross, reported to be poorly constructed but only replaced in 1980s.

St. Mary’s Bridge, Drogheda 1863 – 68. Single 80 foot arch design later revised to a two span, masonry arch structure, replaced in 1984. Construction delays due to first contractor default. Second contractor ended up in legal dispute with Neville and arbitration found in contractors favour in 1868. Tender Cost £6,657.

St. Dominick’s bridge 1863, timber bridge replaced in 1894 by a steel structure still being used by pedestrians.

Unsuccessful in competition for new Carlisle Bridge in Dublin (now O’Connell St Bridge) in 1862.
St Mary’s Bridge, Drogheda
Obelisk Bridge over River Boyne 1868 – 69

Obelisk bridge replaced a wooden structure at Oldbridge near the site of the 1690 battle and was a significant achievement. The obelisk was blown up in 1921!

Single 120 foot span, 11 feet deep, wrought iron, twin lattice girders. Designed by Neville and built by Thomas Grendon & Co. at a cost of £2,540.

In 1869, William Strype gave a highly detailed account of its construction in Vol IX Transactions Institution of Civil Engineers of Ireland. Southern abutment from the earlier bridge was reused. New northern abutment founded on gravel subsoil.

Main girders were manufactured in Drogheda and transported 4 miles to site on river pontoons, set onto temporary supports and incrementally raised 11 feet to the final position using floating supports lifting the beams at each high tide.
Obelisk Bridge over River Boyne
1868 – 69.
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Neville & Railways

Many County Surveyors were involved in planning and construction of railways. Neville and other County Surveyors saw this as a conflict of interest.

Neville took legal action to enforce the reconstruction of two railway bridges and alteration to several others on Dublin and Belfast Junction Railway 1847 - 48. Sir John MacNeil was the chief engineer for the railway and from 1838 – 1842 a young assistant working under MacNeil on railways in Ireland was W. J. Macquorn Rankine!

Neville later opposed an extension of the Dundalk and Enniskillen Railway to the quays at Dundalk.

In 1853 Neville was injured in a serious train crash near Straffan on GS&WR Cork – Dublin express. 16 fatalities and Neville sustained a broken leg and other injuries.
Other Public Works

Plans for dredging, training walls, and a graving dock for Dundalk Harbour 1864 – 69, but not all works were completed.

County courthouse extension 1846

Responsible for design of Louth County Gaol, Dundalk 1853 - 54, subsequently converted and still used as a Garda Station.

Bridewell, Ardee, 1863.
Louth County Gaol, Dundalk 1853
Private Architecture Practice

County Surveyors precluded from working for Contractors but could accept commissions from others. Neville had a thriving private architectural practice:

- Many shops and stores including Martin’s Wine Stores, Dundalk;
- Private homes Shanlis House, Ardee 1858, Dowdstown House and Cardistown House 1865;
- Five chapels and convents for Sisters of Mercy 1850 – 59, at Limerick, Ardee, Dundalk, Omagh and Roscommon. Both his daughters were members of the community.
Convent of Mercy, Ardee 1855
Contributions to Civil Engineering Education

• When John Neville was appointed County Surveyor in 1840, engineering schools were only beginning to be formed in these islands. The Civil Engineering chair in Glasgow was appointed in 1840 and in TCD in 1842.

• Most of those involved in civil engineering design obtained their knowledge from books, published courses in civil engineering and the Encyclopaedia Britannica.

• John Neville contributed to civil engineering education through his following publications:
  - Water pressures on cofferdams 1840;
  - Forces acting on banks of earth, retaining walls 1845 Trans. ICEI & 1847 Proc. RIA;
  - Road cross sections 1846;
  - Hydraulic tables, Coefficients and Formulae for finding the discharge of water from orifices, notches, weirs and rivers, published in London 1853 (reprinted in 1860 & 1875);
  - Hydrodynamics pamphlet in 1858.
John Neville the Person

In her article on John Neville in the Journal of the County Louth Archaeological and Historical Society, Christine Casey comments on John Neville the person. She writes:

• He was a cold an unemotional man, confident and assured by nature, with no time for false modesty nor even at times for diplomacy, and single minded to the point of ruthlessness in the pursuit of quality and efficiency.

She also comments that his report in the spring of 1844 of the death of his assistance county surveyor is shockingly brief and to the point:

• I regret this assistant has been killed by a fall from a horse a few days since and that I will now have to provide another. The report on the county roads has been printed ….."
John Neville and Earth Pressures

“Communication” published in Volume 1: Transactions of Institute of Civil Engineers of Ireland, 1845

“An investigation of some formulae for finding the maximum amount of resistance behind banks of earth, or other materials, and the position of the fracture requiring that resistance”

This communication was read to the ICEI on May 13th, 1845
Design Situation

As a designer of roads and railways involving cuttings and embankments, John Neville wanted to cut off the toes of slopes using small retaining walls, for which the technical term at that time was dwarf walls.
Advantages of Dwarf Walls

The advantages gained using dwarf walls are:

• The act as fences
• Land required is reduced
• Less earthworks
• Toes of slopes neatly defined, protected and permanent – important in districts where cattle or swine abound!
Requirements to Determine the Dimensions of Dwarf Walls

To determine the dimensions of the dwarf wall, John Neville needed the earth pressure $R$ acting on the wall. This depends on:

- The slope (of the ground surface) proceeding from the top of the wall ($\theta$)
- The angle of repose (i.e. our $\phi'$ value)
- The gravity of the stuff, $W$ (i.e. our $\gamma$) – he did not refer to soil or fill but treated both as the same
- The height of the wall, $h$
- The height of the top of the slope within certain limits, $H$

Neville did not show any of these parameters his figures
Objectives of Analysis

Neville’s objective was to determine the maximum horizontal resistance, $R$ required to stabilise the slope.

John Neville examined the stability of the trapezoid $BFCD$ sliding along $CF$.

In order to determine the maximum earth pressure, he needed to determine the inclination of the plane $CF$, i.e. the $\phi$ value, that gave the greatest pressure and hence the largest horizontal reaction required.

Note Neville’s $\phi$ is not the angle of friction, i.e. our $\phi’$. 
Trapezoidal Analysis

John Neville analysed the stability by resolving the forces parallel to CF assuming there were frictional forces $fR$ and $fG \sin \phi$ acting on BC and CF where, using our terminology, $f = \tan \phi'$

$$R \sin \phi + fR \cos \phi + fG \sin \phi = G \cos \phi$$

$$R = G (1 - f \tan \phi)/(f + \tan \phi)$$

Since he needed the max earth pressure, he differentiated $R$ wrt $\phi$ and got

$$\tan^2 \phi + 2f \tan \phi = f m + m/f - 1$$

where $m = \left(\frac{H-h}{H}\right)^2 \tan \theta$.

Solving this quadratic gives $\tan \phi = \frac{\sec c \sqrt{\tan b} \tan c + 1 - 1}{\tan c}$

where $\tan b = m = \left(\frac{H-h}{H}\right)^2 \tan \theta$ and $c =$ complement of the angle of repose so that $\tan c = 1/f$. 
Horizontal Ground Behind Wall

When the ground behind the wall is horizontal:

\[ H = h \quad \text{and} \quad \tan b = \left(\frac{H-h}{H}\right)^2 \tan \theta = 0 \]

And the equation:

\[ \tan \phi = \frac{\sec c \sqrt{\tan b} \tan c + 1 - 1}{\tan c} \]

reduces to:

\[ \tan \phi = \frac{\sec c - 1}{\tan c} = \frac{1}{\sin c} - \frac{1}{\cos c} = \frac{1 - \cos c}{\sin c} = \tan \frac{1}{2}c \]

i.e. \( \tan \phi = \tan \frac{1}{2}c \) or \( \phi = \frac{1}{2}c \)

Neville says this is the equation of Prony

This \( \phi \) value is the inclination of the plane CF giving the maximum value of R, i.e. the active earth pressure
Who Was Prony and What Was His Equation?

Gaspard de Prony (1755-1839)
One of founders of Ecole Polytechnique (1974). First professor of mechanics at that school. In 1798 he became director of Ecole des Ponts et Chaussées. His two books on hydraulics and one on mechanics were widely used in French Engineering schools.

Prony’s equation: \( \phi = \frac{1}{2} c \)

In “An elementary course of Civil Engineering” by JM Sganzin he states:

Prony demonstrated in his Mécanique and formerly in his Mémoire printed in 1802 for use of students that the position of the differential prism at the maximum pressure, is such, that its inferior surface makes with a vertical line an acute angle which is equal to half the angle earth naturally takes (i.e with the vertical!).
Prony’s Equation 1802 and Active Plane

Prony’s equation:

$$\phi = \frac{1}{2} c$$

Expressed using our commonly used symbols today, with $\alpha$ for the inclination of the slope from the horizontal and $\phi'$ for the angle of friction:

$$(90 - \alpha) = \frac{1}{2} (90 - \phi') = 45 - \frac{\phi'}{2}$$

$$\alpha = 45 + \frac{\phi'}{2}$$

This is the angle normally assumed for the active failure plane today.
Charles-Augustin de Coulomb (1736 – 1806) was a French Physicist

In 1764 he was sent to Martinique, in the West Indies, where he was put in charge of building the new Fort Bourbon

Coulomb in 1776 published his paper: “Essai sur une application des regles des maximis et minimis a quelques problemes de statique relatifs a l'architecture“

This was the first study of the problem of lateral earth pressures on retaining structures and used limit equilibrium theory, considering the failing soil block as a free body to determine the limiting horizontal earth pressure, i.e. wedge analysis. He ignored friction between the soil and the wall

His paper was not very readable, using lengths rather then angles, so Prony simplified it in 1802 and presented it in the now familiar trigonometric form

Coulomb leaves a legacy as a pioneer in the field of geotechnical engineering for his contribution to retaining wall design

His name is one of the 72 names inscribed on the Eiffel Tower
Neville’s Earth Pressure 1845

For $H = h$ and using the $\phi$ value to give the maximum $R$ value

Neville’s equation for $R$ becomes:

$$R = \frac{H^2 W}{2} \left( \frac{\sec c - 1}{\tan c} \right)^2 = \frac{H^2 W}{2} \tan^2 \frac{1}{2} c$$

Since $\frac{1}{2} c = \frac{1}{2} (90 - \phi') = \left(45 - \frac{\phi'}{2}\right)$

This gives the equation we use for the active earth pressure:

$$R = \frac{\gamma H^2}{2} \tan^2 \left(45 - \frac{\phi'}{2}\right) = \frac{\gamma H^2}{2} \frac{(1 - \sin \phi')}{(1 + \sin \phi')}$$
Rankine’s Earth Pressure Theory 1857

On the Stability of Loose Earth

W. J. Macquorn Rankine

Phil. Trans. R. Soc. Lond. 1857 147, 9-27, published 1 January 1857

§ 1. General Principle.

The subject of this paper is, the mathematical theory of that kind of stability, which, in a mass composed of separate grains, arises wholly from the mutual friction of those grains, and not from any adhesion amongst them.

Previous researches on this subject are based (so far as I am acquainted with them) on some mathematical artifice or assumption, such as COULOMB’s “wedge of least resistance.” Researches so based, although leading to true solutions of many special problems, are both limited in the application of their results, and unsatisfactory in a scientific point of view. I propose, therefore, to investigate the mathematical theory of the frictional stability of a granular mass, without the aid of any artifice or assumption, and from the following sole principle.

The resistance to displacement by sliding along a given plane in a loose granular mass, is equal to the normal pressure exerted between the parts of the mass on either side of that plane, multiplied by a specific constant.

Fig: Rankine’s planes of limiting stress

Rankine’s equation for the active earth pressure:

\[ R = \frac{\gamma H^2 (1 - \sin\phi')}{2 (1 + \sin\phi')} \]
Angles of Repose

Neville says most materials in a loose dry state have angles of repose (i.e. angle of friction, $\phi'$) between 34° and 40° and material stands on slopes at slopes between 1¼ to 1 and 1½ to 1 nearly (i.e. 33.7° to 38.7°)

However, if the stuff or plane of fracture, CF, becomes saturated with water, the friction on the plane is reduced thereby and the angle of repose becomes flatter

He notes that it appears that through the agency of water reducing the friction, the resistance required is double that required when stuff is dry

This is consistent from what we now understand through effective stress analysis that the safe angle of an infinite slope is reduced by one half when water rises to the surface

Hence, he states, the necessity of cutting or draining off water from the back of banks, slopes and retaining walls
Rossberg Great Fall

Neville says springs are the most general cause of landslips and as example refers to the great fall of the Rossberg in Austria in 1806.

He quotes Phillips’s Geology: “This is a case of this kind where water entered and moistened a particular layer of strata, all inclined very highly, so as easily to acquire a descending force, if the cohesion of the parts were weakened by the interposed moisture.”

He then states “water lubricates (!) fissures, decreases friction, and increases the value of R”

The 1806 Goldau landslide event—analysis of a large rock slide by K. Thuro & M. Hatem (2010) in Geologically Active – Williams et al. (eds)

The Swiss physician Dr. Carl Zay, who witnessed the landslide of Goldau said September 2, 1806 the Swiss village of Goldau was destroyed by a landslide, with an estimated volume of 40 million cubic meters, coming from the Rossberg. 457 people were killed - one of the greatest natural disasters in the Alps in historic times.
Stepped series of sliding planes at the Rossberg: Plane (1) prehistoric slide, (2) 1222 Röthen slide, (3) 1806 rock slide, (4) 2002 Gnipen rock slide, (5) 2005 Gribsch rock slide—debris flow, (6) signs of slope movement (future event?). Debris material and present-day village of Goldau and Oberarth.
Neville and Tredgold

Thomas Tredgold (1788–1829) was a highly respected pioneering civil engineer and the person who gave the influential definition of civil engineering on which the charter of the Institution of Civil Engineers based itself in 1828 and which includes the phrase:

Civil engineering is “the art of directing the great sources of power in Nature for the use and convenience of man”

In 1843 Tredgold published a Table of retaining wall dimensions in the seventh edition of the Encyclopedia Britannica, i.e. 2 years before Neville published his paper

Neville was very critical of these table. He wrote in his paper “they must appear, to a practical person, as worse than useless, and it they has been shown that the dimensions for leaning walls have been calculated for an amount of resistance only half of what it should be”

The error Neville found was that the term $\frac{\tan c + 1}{\tan i}$ in Tredgold’s equation for $R$ should have been $\frac{\tan c \tan i + 1}{\tan^2 i}$ where $c$ is the inclination of the back of the wall and $i$ is complement of the angle of repose

If $c = 0^\circ$ and $i = 90 - 30 = 60^\circ$, then $\frac{\tan c + 1}{\tan i} = 0.58$ and $\frac{\tan c \tan i + 1}{\tan^2 i} = 0.33$
Neville’s Conclusions on Earth Pressures

• Neville states that R is the most important element involved in the equations for determining the dimensions for retaining walls.
• Groundwater is the dominant cause of slips in cuttings.
• Non-planar failure planes are often observed in practice.
• When stuff is tipped into embankment, the angle of repose is least, and when adhesion and consolidation take place it is greatest.
• He noted the dangers of surcharge loading to the stability of quay walls and cut slopes.
• Failure may not take place immediately after a fracture in the bank takes place but after it is penetrated by water, when the angle of repose is reduced and perhaps also hydrostatic pressure is brought into play.
• Hence the necessity of the taking the maximum value of R; and the prudence of the engineering maxim “stronger than strong enough.”
• All these demonstrate an impressive insight into the real behaviour of soils and could be made by any geotechnical engineer working today.
Summary as an Engineer

- Neville was a very distinguished engineer and one of the longest serving County Surveyors.
- He was involved in the design and construction of many public works including roads, bridges and public buildings.
- He operated a successful architectural practice.
- He had a very good understanding of engineering principles.
- He was aware of recent engineering theories from Paris and was aware of what was happening in Europe, e.g. in Austria.
- His mathematical and analytical skills were very good and he contributed to early civil engineering education and Continuing Professional Development through his publications.
Acknowledgements & Bibliography

Ron Cox, TCD instigated our research in 2012 and provided photos of Obelisk Bridge.

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