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Local tectonics – Danish architectural construction in historical environmental perspective.

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ABSTRACT. The paper discusses architectural tectonics in local geological context. With point of departure in Denmark, the paper provides a brief outline of historical constructional practice as result of geological and environmental conditions, from wood over half-timber to brick stone and concrete. Each material with its inherent structural potentials developed into architectures with specific tectonic characteristics.

1 INTRODUCTION

Architectural construction has historically been profoundly dependent on local environmental conditions in terms of climate, topography, geology, and natural resources. The twentieth century, characterized by an abundance of cheap fossil fuels, exploitation of hitherto unreachable resources, global trade and a modernist movement favoring international style, eased the dependence. The consequences of unlimited building practice are now showing in form of climate change and scarcity of a number of raw materials, and stratigraphic scientists claim Earth has now reached the geologic epoch of Anthropocene (Anthropocene, 2021). Lack of sustainable practice calls for renewed awareness of local environmental conditions framing building activity and architecture.

There are two major understandings of the term *Tectonics*. In geological context, 'tectonics is the study of the structural geology of the Earth [including] the creation, destruction and rearrangement of the Earth's crust and lithosphere' (Tectonics, 2021). In architectural context, the term tectonic - deriving from ancient Greek *Tekton*, meaning builder - had its modern revival with Kenneth Frampton's book *Studies in Tectonic Culture* (Frampton, 1995). The book's subtitle, *The Poetics of Construction* […], may serve as a broad definition of architectural tectonics. Being skeptical towards abstract, international modernism as well as whimsy postmodernism, Frampton aims to highlight the architectural potential of construction and materiality in site-specific context. With point of departure in Denmark, this paper aims to connect the two notions of tectonics by providing a brief outline of historical building practice as result of geological and environmental conditions.

2 THE GEOLOGICAL DEVELOPMENT OF DENMARK

The Danish territory is an archipelago encompassing the peninsular Jutland and 406 islands. The country has app. 7300 km coastline, and the highest point reaches 173 meter above sea level. It is geologically part of the Northwest European basin and lies along the southwestern brim of the Baltic Shield bedrock, which now lies app. 1 km below ground and comes to surface only on the Eastern Island Bornholm. Through 500 million years, the territory alternately lay below and above sea level, receiving sediments of sand, clay, marl, anhydrite, salts, chalk, and lime. The Danish landscape took shape predominantly during the Weichsel Ice Age: 16.000 B.C., the ice

cap covered most parts of the country, leaving only the Southwestern part of current Jutland uncovered. Melting water from the ice cap overflowed this uncovered area and buried the lower parts in sand and gravel. This has remained a flat, sandy, and less fertile landscape. During the next millennia, the ice cap drew back and forth pushing the Northeastern landscapes around and mixing the different sediments, leaving a hilly, moraine landscape and a soil being a mixture of sand, clay, gravel, and lime. This has become the most fertile part of the country. The ice cap had been up to 2 km thick, pressing the earth's crust down. As the ice melted the land rose again. The Northern part of Jutland still lay below sea level and was flooded with fine sand until it finally rose to become dry land, later with medium fertility (Humlum, 1996).

13.000 B.C. the ice cap left a rocky park tundra with chumps of lime, and with water everywhere in the form of creeks and ponds (Jensen, 2013, p. 26-27). With summer temperatures reaching 8-9° Celsius, only low, robust vegetation like sea buckthorn could grow. As the climate got warmer, large parts of the tundra gained the character of an open birch forest, occasionally supplied with rowan, willow and pine. Reindeers entering the territory attracted the first human hunters leaving traces of flint tools. Due to the low sea level, you could walk from Jutland to England, but 6.000 B.C. summer temperatures had reached an average of 18° Celsius; the ice cap had melted withdrawing far north leaving higher sea levels, and the country slowly gained its current shape. Forests now covered the country coast to coast; first pine with chumps of hazel and lighter areas dominated by birch; later on, elm, oak, linden and ash, providing habitat for a great variety of animals, and materials and fuel for bonfires for human beings, while adding organic substances to the topsoil (Jordbunden, 2021). Hunters and trappers must be on the move. Their settlements were temporary, predominantly coastal, leaving remnants of shell middens but no evidence of building construction (Jensen, 2013, p. 51-52).

3 THE WOODEN PEASANT LONGHOUSE

The first clear evidence of house building coincides with the establishment of agriculture, 3.900 B.C. Peasants settled by their fields, establishing long-term shelters against the climate. Traces of vertical wooden posts dug into the ground indicates the supporting structure and thus the house type: A longhouse running east to west, 10-18 m long and 4-6 m wide, the north and south façade supporting a gabled roof, and with rounded walls to the east and west. A few posts placed centrally in the house carried a longitudinal central beam that the gabled roof rested upon (Jensen, 2013, p. 140-142). The walls may have been wattle and daub, roof made of straw, and the house having earthen floors. The small house size indicates a one family-house, while several houses might group in small settlements. The longhouse is a remarkable steady house form that runs through Danish history from Stone Age up to 20th century farm building. The orientation is in a predominant number of cases east to west with small variations. The Danish territory experiences relatively strong western winds, while the winter has cold winds from the east. The flat terrain surrounded by sea offers little resistance to the winds, so the house must situate to endure and shield its habitants from the wind and the cold, while the long southern façade draws heat from the sun.

Around 2000 B.C., cultures north of the Alps developed copper-based alloys forming them into weapons and other tools. They traded their goods north and south, thus Scandinavian tribes slowly got in indirect contact with the highly developed Mediterranean cultures. The Bronze Age brought metal tools and weapons, social division and occasional prosperity reflected in longhouses gaining size, now being up to 45 m long and 8-9 m wide. 500 years later, the increased width had resulted in a new supporting structure type: Inside the house, two rows of posts supported an aisle plate carrying the roof, turning the house into a small three-aisled basilica (Jensen, 2013, p. 344). Due to a colder climate in this period, the farm animals moved into the house occupying the eastern part, humans resided in the west. While the Stone Age country covered in forests only occasional had clearings occupied by humans, thousands of years of agriculture turned parts of the territory into an open landscape interrupted by solitary trees and bushes, groves, forests, and marsh. As the available Central-European copper resources diminished, around 500 B.C. iron took over as the dominant metal, in the Danish territory eventually extracted locally, mainly in the Southwestern part of Jutland where the soil was sour providing optimal conditions for the development of bog iron. The villages moved around within the local area: After a generation or two, the earth-dug posts would decay, and houses rebuild in a new place. The old place, where

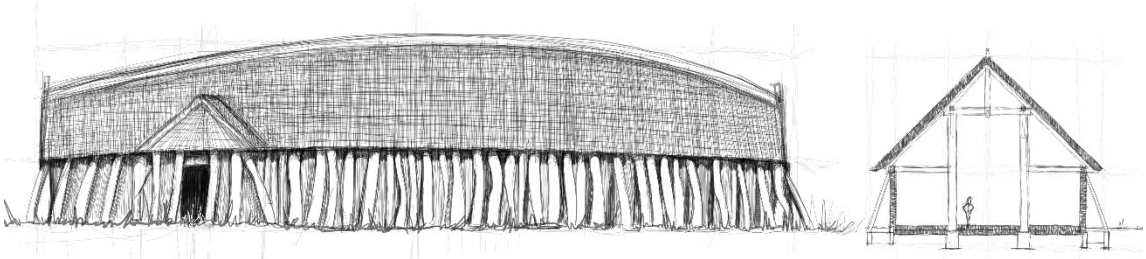

Figure 1. Viking Kings Hall, Sagnlandet Lejre 700 A.D. (rebuilt 2020) *(Emilie Hellerup.)*

humans and animals had lived for decades, would be rich on fertilizer and transform to agriculture (Jensen, 2013, p. 563-578). During the Roman Iron Age 0 - 400 A.D. the territory became a densely populated agricultural society. The forests were in retreat and the sandy areas of Jutland had been overused, now decaying into a vast heathland where very few peasants could endure.

4 THE VIKING MAGNATE HALLS

From 500 A.D., a large elite settlement developed in Lejre on Zealand, considered the central location of the first Danish kingdom. Two hundred years later an impressing magnate hall established, that should stand for 300 years. The Old-English heroic poem Beowulf speaks of Beowulf and his companions visiting the king, where 'the hall they saw, broad of gable and bright with gold: that was the fairest, 'mid folk of earth, of houses 'neath heaven'' (Grummere, 2021), probably the first written statement on Danish architecture. Archeology speaks of an east-west going magnate hall, 48 m long, 11,5 m wide in the middle and 8 m wide at the gables. The fact that the hall narrowed in at the gables, also meant that the ridge of the roof curved down towards the gable giving the house a ship-shaped form. The magnate hall had not only indoor vertical posts but also oblique posts along the outer walls would support the roof; probably the first time such a construction manifested on Danish grounds (Jensen, 2013, p. 954-957). The curved walls and roof had now become common building practice also in ordinary peasant's much smaller longhouses and the iron age-hipped ends had gone and been replaced by vertical gables. Around 980, Danish Viking architecture culminated with the construction of circular fortresses spread over the country, as a manifestation of a regionally strong Danish kingdom. Most fortresses consisted of 16 ship-shaped longhouses each of them approximately 30 m long and with construction principles similar to the hall in Lejre, only were most of the indoor vertical posts now gone leaving a huge room free of supports under a roof stabilized by external oblique posts. The 16 longhouses constituted four squares surrounded by a circular mound of earth. In scale, geometric precision, and tectonic ambition these military fortresses ranged far above anything ever seen on Danish grounds. The circular form resembled contemporary Carolingian fortresses on Netherland coasts, but the shape and organization of the houses were genuinely Danish (Jensen, 2013, p. 991-999). Like all constructed until this time, the main material was wood, the most important remnants are signs of earth dug posts, and the houses are all gone.

5 TRAVERTINE AND STONE

As the Viking-regime and its wooden architectural efforts culminated around the turn of the millennium, in Aachen just 600 km south of the Danish border emperor Charlemagne's octagon stone chapel had stood for two centuries and still stands. The far-travelling Vikings must have been well acquainted with huge stone buildings especially in the form of churches and chapels. In Denmark, the transition from Nordic mythology to Christianity lasted from the ninth to the 11th century when several small wooden churches stood around the country. Soon after, travertine came into use, a porous limestone developed where water rich on calcium spreads over vegetation. Such processes began shortly after the last ice age in the hilly moraine parts of Denmark where the ground is rich on chalk. Travertine is easy to cut when it is fresh and wet but hardens when it

dries up. Approximately 100 Danish middle age churches stand in travertine. They are often plastered and whitewashed, to prevent the porous stone from decomposition. Due to intense use, travertine nowadays very seldom occurs on Danish grounds. The dominant part of early Middle-Age (1050-1200 A.D.) churches were made of boulders, natural rounded granite stones laying spread over the country after the last ice age. When used for church construction they might maintain their original shape or be cleaved into more rectangular forms. Boulders were since the Stone Age used for graves and memorials, but now cleaving and cutting them into building blocks were a demanding and high-skilled task. Nevertheless, around 1.050 stony village churches stand around the country, in most regions constituting the only surviving part of early middle age architecture, predominantly one shipped basilicas in Roman style and with horizontal wood ceilings. Compact, heavy, greyish, and bold constructions with small high-positioned windows, suited for spiritual worship as well as refuge and defense in case of assault and siege (Nørregård-Nielsen, 2006, p.59-61).

6 BRICKS AND TILES

The brick is beyond compare the most dominant building component in Danish architecture. Sct. Bendt in Ringsted inaugurated in 1170 ranks as the first brick church in Denmark. Probably a master builder from Lombardy and his crew came up to Zealand (Nørregård-Nielsen, 2006, p. 85) to build the tall and firm cross-shaped building and did so in a well-articulated manner showing the great architectural potential of the brick. To endure in a Nordic context, a brick must burn at a temperature of 900 to 1150°C for 8 to 15 hours thus demanding lots of fuel (Nørregård-Nielsen, 2006, p. 30), and local brickworks had to be established. Different types of clay occur in the Danish territory. Most of the clay used for building purposes dates to the last Ice Age. Sandy and stony moraine clay appears on Zealand, Funen, and the moraine parts of Jutland, while the high-quality 'melting water clay' (the Danish term is 'issøler' = ice sea clay) free of stone appears on Zealand and Funen (Ler, 2021). One differs between red clay (burned to red bricks) and blue clay (burned to yellow bricks). It is the balance between iron oxide and calcium, which decides the color. In the upper and easily available layers from where the calcium washes out over time, one will find red clay. It is therefore natural that the first many centuries of Danish brick building were done in red bricks, though there are subtle color differences across the country, from the brownish almost purple, over red to ocher (Nørregård-Nielsen, 2006, p. 6). Bricks became the dominating building material in churches, monasteries, castles, and defense works in the Danish kingdom. Early on, local builders obviously doubted the strength of the bricks and applied pillars and corner stones of granite to secure a strong supporting structure (Nørregård-Nielsen, 2006, p. 123) , but they soon got confident and as the gothic style entered, were able to erect soaring basilicas and ceiling vaults in the new material. With inner walls, ceilings, and flooring all in bricks, and with outer walls in red bricks and roofs in red tiles, Danish master builders had a material that constituted all essential parts of a building to provide a homogeneous heavy outlook expressing power and unity. As the power of overlords increased, they applied bricks and tiles in their estates and on many occasions, bricks from worn-out buildings found use in new contexts. Among Danish kings, Christian IV reigning 1588-1648 stands out, turning the fleet into one of largest in Europe, developing Copenhagen into a strong capital with brick buildings for central administration as well as navy personal, and building several rural castles around the capital. The military expansion went on in the following centuries causing a huge consumption of timber for boats and buildings, the military being a main cause in reducing the Danish Forest area from 20-25% around 1600 to 8-10 % around 1750 (Kjærgaard, 1991, p. 20).

7 HALF TIMBERING

Ordinary peasants continued the building practice laid out in the Viking Era. Three-aisled wooden basilicas dominated the first post-Viking years, but soon gave way to a one-ailed type. The curved facades characterizing the Viking style stayed in use until around 1200, where it finally gave way to straight facades. The first few examples of stone foundations occurred in the 11th century, but the new construction principle spread very slowly (Skov, 1994). Digging wooden

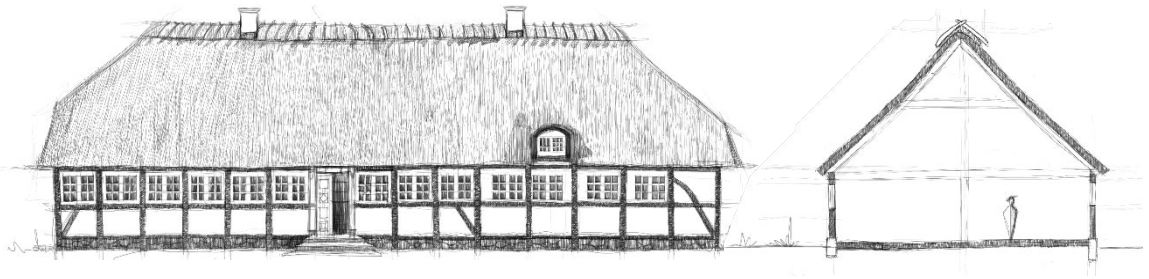

Figure 2. Inspired by Vester Skerninge Tavern, Anders Kromand, 1722. *(Emilie Hellerup)*

posts into the ground had long been an easy but non-durable way of providing stable construction. Tapping horizontal oak-planks into vertical posts also required large quantities of timber, but despite repeated royal prohibitions of earth-dug posts as well as post-and-plank constructions, the use of such constructions continued way past medieval times (Vensild, 1994).

Placing a house on top of foundation stones, required new ways of securing stability in the supporting structure and across 7-800 years half-timbering techniques would evolve. The Danish term '*bindingsværk*' or 'binding work' better expresses the task of the timber. The first and most important invention was the use of joists, a suspended floor above the rooms for living structurally dividing the house into a rectangular box with a triangular roof. The façades were 'weaved' in timber: On top of the foundation stones, a sill supported posts running up to the wall plate supporting the roof. In between the posts, most houses would have noggins supplied with braces on the corners of the building securing stability in the windblown landscape. All joints would be wooden. On Funen and in Eastern Jutland rich on timber, the constructions would predominantly be oak and in large dimensions, often with extra studs between noggins and sills, and all tarred in contrast to the whitewashed infill boards. On Zealand, where royal and military demands were high and forest reserves increasingly low, the timber construction were poor and therefor whitewashed along with the boards. In medieval times the boards had typically been clay and mud, centuries later they might come as bricks. The roof would be straw or roof pipes, alternatively heather or seaweed. In the 17th century, partly closed fireplaces started to occur, but it took several decades before chimneys and iron stoves became a natural part of peasant dwellings (Brogaard, 1980, p. 29-37).

The fully developed Danish half-timbering house constitutes a type of strong tectonic character. Granite stones forms the heavy foundation, lifting the house above grounds. The tarred half-timbering itself stands out in contrast to the bright-colored infill boards, and gives clear visibility of the supporting structure, a scholarly example of telling of structural forces. The bulging organic roof tells of protection against rain and cold, a tectonic tale of heat insulation that is absent in modern architecture. The chimneys tell of cooking and heating, the essence of Northerly dwelling.

8 ECOLOGICAL BREAKDOWN

Through Danish history, wood had been the all-dominating raw material when it came to rural house construction, enclosures for animals, tools for field and domestic work, and for heating. As the population grew and military forces expanded, the forests shrunk reaching an all-time low of only 2-3 % of the country covered in forest around 1800. This had severe consequences. As there were no trees to suck up water, the grounds got swampy and cultivating the fields had to start later and finish earlier in the season if not to sink into mud. The wet grounds got sour. Both phenomena decreased the production of crops. With sparse wood, the houses did not heat fully, and tuberculosis returned as a common disease. With sparse timber, new houses could not construct. When huge national land reforms implemented 1790-1830, the farms physically moved out of the villages in which they had grouped, to construct on new individual sites. On these occasions, the half-timbering constructions could relatively easily disassemble and reuse in the new terrain.

The 18th century saw huge ecological recovery works in the form of drainage and liming of fields (Kjærgaard, 1991). Effective iron ovens diminished the need for fuel. Still, the country was strongly in need of import of wood substitutes. Fuel wise, in the form of hard coal from England.

Figure 3. Inspired by Bakkekammen 45, Ivar Bentsen & Marius Pedersen, 1929 *(Emilie Hellerup.)*

Additionally, there were much energy embedded in imported products like timber, glass and above all, iron. Danish glass production had ceased in 1707 due to shortage of fuel. The country had large reserves in form of bog iron, but shortly after 1600 A.D., domestic production ceased due to shortage of fuel to extract the iron. Now, iron products were imported mainly from Norway, in the form of ploughs, harrows and iron stoves. From the 18th century, the Danish society got dependent on imported energy and could not sustain without (Kjærgaard, 1991, p. 110-121).

9 BRICKS FOR ALL

Entering the 19th century, huge quantities of pine was imported from Norway and Germany. Half timbering remained the cheapest way of building for some decades but at the end of century, the vast majority of rural dwellings constructed in red brick (Faber, 1977, p. 106). So did the many cooperative diaries and other local industries that flourished in the countryside in the second half of the century. Towns and villages experienced the same development starting in Copenhagen, where in 1728 and 1795 huge fires had destroyed major parts of the medieval, half-timbered city. Now it rebuilt in bricks. As the classicist style reigned from app. 1750 to 1850, many brick constructions had plastered facades, but as historicism took over red brick walls dominated once again, occasionally in patterns shifting between red and yellow bricks. Bricks had become the national material most evident in the national-romantic style developed at the turn of the 20th century with the red-bricked Copenhagen Town Hall from 1905 as the outstanding example.

The Nordic countries characterizes by architectural concern also for the poor and the middle class. In 1915 '*Bedre Byggeskik*' or 'Better building practice' saw the light of day, an organization driven by architects and master builders providing courses for builders and craftsmen as well as architectural drawings at a low price for ordinary people, who wanted to build a modest house (Floris, 2005). This secured high standards and fine detailing of the many single-family houses built in the first half of the century, typically prismatic buildings with no eaves but often with semi-hipped gables, an almost square floor plan and a chimney in the middle, an optimal volume to surface ratio, a bold house kept in classic order. With red brick walls, red tiles and a small chimney in red bricks, the ultra-compact type has been referred to as 'the house as lump' as if cut out of red clay in one piece. In the cities, housing organizations built multi-story housing for a growing population including the many people leaving agriculture to settle as industry workers. The buildings were modest and quiet, compact, and orderly, but with a fine detailing in red or yellow brick stones as the architect and the master mason spoke the same language. From the middle of the 19th to the middle of the 20th century, bricks were the all-dominating building material and visual appearance of monumental as well as minor buildings, representing a thorough tectonic and craft quality not surpassed since then.

10 CONCRETE

Danish topsoil layers of humus, sand, and clay rests on a layer of chalk, a main ingredient of cement that is the most prevalent binder of concrete with sand and gravel being typical aggregates. The invention of Portland cement (1824) and reinforced concrete (1849) paved the way for modern day production and use of concrete and in the twentieth century, Danish F.L. Schmidt with

Aalborg Portland became the world´s largest producer of cement and of plants to produce it. In 1892, the first Danish harbor constructed in concrete, and it soon found use in bridges, industrial plants and as building foundations due to its strong durability in wet environments (Synlig beton, 2021). Danish housing construction largely remained a brick stone craft phenomenon until the late 1950'ies, when high demands for new housing and shortage of bricklayers caused Danish governments to insist on industrialized concrete element-construction if to support social housing (Nygaard, E. 1984, p. 91-161). From 1960 to 1975, the Danish housing stock doubled in an unprecedented building boom. While the vast majority of the single family-houses appeared as brick houses, multi-story apartment houses stood in grey concrete, grouped in large monotonous settlements sometimes the size of cities and with a rectangular, repetitive design far from the plastic potentials of concrete construction. Concrete became synonymous with a dull, schematic appearance (Synlig beton, 2021) and became disfavored for external cladding, but has up to present day remained the dominating supporting structure of multi-level buildings due to its constructive strength, fire safety and construction economics.

Upon the seventies oil crisis, building regulations demanded better insulation of buildings and avoidance of cold bridges. External walls were previously constructed as cavity walls, but the inner and outer wall connected around doors and windows in brick as well as concrete walls. Now, insulation hidden behind the window frame disconnected the two walls. The outer wall was no more part of the supporting structure, and could take the form of wood, thin metal sheets, asbestos cement, or screen tiles. Tectonically, there was no longer an expression of the supporting structure, and the Bauhaus dogma of 'honest architecture' or 'truth to materials' were replaced by the postmodern 'anything goes'. In the 21st century, multi-story buildings typically construct with partition walls, decks and inner walls made of concrete, while the outer wall is made of bricks. In some cases, the walls may consist of a concrete inner wall, followed by a thick layer of insulation finished by a layer of plaster on the outside surface to imitate heavy construction. Only if you knock on them and they give a hollow sound, they will reveal as fake heavy constructions. Low-rise houses typically construct as porous concrete covered with facades of bricks.

11 DISCUSSION

Present time characterizes by overshooting of ecological boundaries and as history tells, architecture will have to adapt to environmental conditions. It will have to mitigate its impact as well. Contemporary architecture must reflect a much wiser usage of resources than pre-industrial as well as present practice. Using local materials cannot be the single overarching strategy. Rather life cycle assessment must provide balanced information of the environmental impacts from all phases of building activity. Yet, transportation of heavy materials over long distances represents a huge negative impact, wherefore a local and regional perspective on supply is still relevant.

For half a century, the Danish legal frames for heating etc. has tightened to such a degree that in new buildings the energy embedded in construction materials and the related greenhouse gas emissions now surpasses the GHG for operating the building in its entire lifetime (Birgisdóttir, 2017), especially true for heavy constructions. Unlike other countries, Denmark does not face acute shortage of sand, gravel, stone, or clay, but open mining often collides with local 'not in my backyard'-interests (Kullberg, 2020). At the same time, building waste constitutes 40 % of the national production of waste (Miljøstyrelsen, 2021). These problems points toward reuse of mineral materials, which is often physically possible, but calls for new aesthetics. New constructions based on reused fractions may have traces of use and patina while the colors and textures may differ. The visual appearance may be 'worn' or even collage-like, far from the slick and homogenous aesthetics of modernist architecture. Most timber for Danish building construction imports from neighboring countries Norway and Sweden with the advantage of being renewable and having potential for carbon-dioxide storage. As opposed to other Nordic countries, Denmark has no tradition of organic high-rise construction wherefore such practice needs experiment and experience. Danish mineral and organic tectonics need to develop, if to constitute a genuine Danish building practice. Environmental concerns raises the question whether to construct new buildings at all, or rather transform existing structures into having new functions and high-level energy and indoor climatic performances. Such practice calls for an integrated understanding of the architectural as well as constructive qualities of historic buildings.

12 CONCLUSION

In a time characterized by climate change and urge for sustainability, circular building practices and tectonics need to develop. As this brief historical outline shows, climate change, deforestation, flooded grounds, ecological breakdown, material and fuel shortage and decline of human health are all historic phenomena. But so is climate adapted architecture, reuse and design for disassembly. Historically, material shortage has resulted in development of building practices with new but still evident architectural tectonic quality in light, heavy and hybrid construction.

Architectural tectonics are deeply dependent on geological tectonics, the terrain, vegetation and climate that constitutes local environments. Such relations rarely documents. Architectural history often focus on style and aesthetic expression, while engineering history remains almost absent and un-written. Architectural tectonics has a food in both camps. History needs re-writing in a much more integrated manner if to provide knowledge and support for future architectural construction.

REFERENCES

Anthropocene: http://quaternary.stratigraphy.org/working-groups/anthropocene/ Assessed 22.10.21.

Birgisdóttir, H. & Madsen, S.S. 2017. *Bygningers indlejrede energi og miljøpåvirkninger. Vurderet for hele bygningens livscyklus.* Forskning i det byggede miljø, SBi 2017:08. Polyteknisk Forlag ApS, Kongens Lyngby.

Brogaard, P. et al.1980. *Danmarks arkitektur, Landbrugets huse*. Gyldendal

Frampton, K.1995. *Studies in Tectonic Culture. The Poetics of Construction in Nineteenth and Twentieth Century Architecture*. MIT Press.

Faber, T. 1977. *Dansk Arkitektur*. Arkitektens Forlag.

Floris, L. 2005. *Bedre Byggeskik. Bevægelse og bygninger*. Holbæk Museum/Thaning & Appel.

Grummere, F.B. (transl.) *Beowulf* (modern English translation) By Anonymous. https://www.poetryfoundation.org/poems/50114/beowulf-modern-english-translation Assessed 22.10.21

Humlum, O. 1996. Danmark. Geologi. Landskabets dannelse. In *Den Store Danske Encyclopædi.*

Jensen, J. 2013 *Danmarks oldtid. Fra stenalder til vikingetid*. Gyldendal.

Jordbunden: https://naturenidanmark.lex.dk/Jordbunden Assessed 22.10.21.

Kjærgaard, T. 1991. *Den danske revolution 1500-1800. En økohistorisk tolkning*. Gyldendal.

Kullberg, T et.al. 2020. Mineralske råstoffer, bæredygtighed og innovation. MiMa & GEUS, København.

Ler: https://denstoredanske.lex.dk/ler Assessed 22.10.21

Miljøstyrelsen (2020) Affaldsstatistik 2019. https://mst.dk/affald-jord/affald/affaldsdatasystemet/find-affaldsdata/affaldsstatistikker/ Assessed 22.10.21

Nygaard, E. 1984. *Tag over hovedet. Dansk Boligbyggeri fra 1945 til 1982*. Arkitektens Forlag.

Nørregård-Nielsen, H.E. 2006. Magt og dragt. Dansk teglstensarkitektur. Gyldendal.

Skov, H.: Hustyper i vikingetid og tidlig middelalder. In:1994. *Hikuin 21. Landbebyggelse i middelalde ren*. Forlaget Hikuin.

Synlig beton: https://www.synligbeton.dk/arkitekturhistorie/ Assessed 22.10.21

Tectonics: https://www.nature.com/subjects/tectonics. Assessed 22.10.21.

Vensild, H: Jordgravede stolper, fodtømmer og andre 'jordnære' bygningsforhold i Skast Herred1636-1800. In: *Hikuin 21. Landbebyggelse i middelalderen*. Forlaget Hikuin.