Lofty ideas – timber in the urban jungle.

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I have never stood at the base of a giant redwood and tried to see the uppermost leaves swaying some 100m in the sky. I think if I had done so as an engineering student my conversion to timber construction would have happened sooner. Instead I immersed myself in steel and concrete design at University (timber was not even an option) and subsequently spent the first 15 years of my career exclusively designing in them.

As it is I am a relative newcomer to the virtues of timber engineering, with nearly ten years of experience compared to the giant redwoods 1000+ years, I imagine I still have lots to learn. For example, if someone gave me 1000m^3 of timber (about the amount in a giant redwood) what could I usefully do for society with it? Well strangely enough someone has already answered that question and built Stadthaus in London, the UK's tallest timber building. At nine storeys or 25m it might have some way to go before it competes with the giant redwood but I honestly can't think of a better use for timber.

My conversion to timber happened in 2002 with an introduction to cross laminated timber. Since seeing the first building completed in 2004 I have been involved in the design and construction of about 40,000m^2 of timber structures in the UK, the largest to date was the Open Academy in Norwich. It is impressive to see over 3,250m^3 of timber form a 10,000m^2 building in 18 weeks. However, converting others to the merits of building big in timber is not an easy mission. For every building completed at least three have failed and gone steel or concrete.

So is building big in timber the future……how high can we go? Is it an efficient use of material? Is there enough wood to build more and more in timber? Is it the best use of our forest resources? Most importantly can it be done sustainably?

Urbanisation is a global trend and in the UK this is mainly fuelled by a growing population. The UK is tightly packed and as urban environments become denser the urge is to build up rather than out. If timber is to compete as a future construction material then it has to embrace this urge. New products such as laminated veneer lumber (LVL), cross laminated timber (CLT) and parallel strand lumber (PSL) have certainly played a part in driving our designers' ambition to build tall in timber. Recent proposals from the UK, Canada, Norway and Australia are stretching the limits and the current thinking is that 20 (and more) storey structures are now technically and financially possible.

A recent research exercise at Cambridge University stretched way beyond to nearly seventy storeys, identifying the theoretical failure points of a cellular CLT construction and subsequently working with chemists to design a new type of monomer that would impregnate timber to strengthen connections. The study highlighted that critical to building tall in timber are connections and construction methods (ie platform construction versus balloon frame). Repetitive and stacked floor plans enabled timber walls to rise the full height of the tower. Without the cross grain interruption of floor plates at the wall on wall junctions the structural 'squashing' from gravity loads were no greater than a steel or concrete frame of similar height. Where tall timber potentially differs from tall steel or concrete is in how it deals with lateral loading (ie wind or seismic loading). The lightweight nature of timber construction means that it is more susceptible to tensile stresses developing under lateral loading and this causes problems. The Cambridge study overcame this by developing a building form that eliminated tensile forces, the tapering shape of the tower reduced wind loading and base dimensions where increased, creating a relatively squat profile in elevation. Certainly architects and engineers will need to work harder in timber to develop towers that don't appear bulky or become too rigorous in their internal space planning. The next chapter in tall timber is unlikely to be dictated by the perfect timber structure, more likely it will be a compromise between the demand for dynamic space (mixed use towers) and efficient structure. If tall is the future then certainly engineered and modified timber are required but we should also make sure we don't overlook options for hybrid structures, marrying steel or concrete with timber. By mixing materials we will also be able to overcome some of the early supply problems that a new product such as CLT has suffered, the Cambridge tower would require all CLT factories in Europe to dedicate production to its cause for nearly one year if it were to be realised.

To date limited study has been undertaken on the resource efficiency in timber construction, especially comparing tall with short. Whilst there are economies in urban environments in energy required for transport and building operation, building tall will use more engineering materials. Studies in steel and concrete structures have indicated that the penalty may be anything from 30% to 100% more materials. The Burj Khalifa in Dubai, currently the world's tallest building at over 800m uses some three times more concrete than a medium rise version of the same floor area. This statistic is even more bizarre when you realise that space is available in Dubai to spread out (and not up) and create human scale habitats, similar to Shibam, that would also use less energy in their operation. If you haven't heard of Shibam you really should look it up, 11 storey load bearing 'mud' buildings in the Yemen desert, a great example of centuries old sustainable construction and architecture that responds to the climate.

Back to tall in timber, the Stadthaus project uses approximately 900m^3 to create 29 apartments or 1850m^2 of living space. At nearly 0.5m^3 for every square metre of floor space created this would seem like a lot of timber. However, one could argue that lots of timber locked up inside a building for 60 years is a good idea…..carbon capture and storage at a beautifully simple level.

Whilst resources and energy remain cheap and the cost of thinking expensive *(see Prof Mike Ashby 'Materials and the Environment: Eco-informed Material Choice' published by Butterworth and Heinemann)*, there is unlikely to be an incentive to squeeze greater efficiencies out of engineering design. A construction industry that moves towards pre-fabrication may counter this argument.

So, is there enough wood in our forests to build more and more in timber? The latest edition of the 'State of the World's Forests – 2011' would suggest that there is – in particular in Europe. The EU27 countries are doing quite well in increasing forested area and squeezing more m^3 per hectare in to our forests. In 2011 there was 240,000,000m^3 of growth that was not harvested (about 35% of total growth). When you consider that the UK consumes some 15,000,000m^3 of wood annually there is potential to do lots more with (other countries) wood. In the UK we are still wood averse, per head our consumption of sawn wood is only half that of Germany and less than a quarter that of Sweden. Whilst doubling our use of wood in the UK would mean more imports, the carbon cost of transport would be small compared to the potential for 10million tCO2 to be locked up inside our buildings or other timber products. Why not set up three CLT manufacturing plants in the UK each producing 75,000m^3 of CLT annually (or 250no. Stadthauses a year)? Felixstowe, Hull and Newcastle could become centres of UK timber manufacture with timber arriving by sea from Sweden and Finland. Instead of just importing finished projects in to the UK, the UK would be able to add value through manufacturing and fabrication. Our architects and engineers certainly have the appetite to take on the design challenge of designing tall in timber; investment is needed in manufacture to match their ambition.

So can all this be done sustainably? The good news is that our European forests have a bright future and in fact we need to make sure we harvest more wood and subsequently build more with it, locking away carbon in buildings for the long term. So if we manage to overcome the perceived risks of fire, decay and squeaky floors associated with timber could we build everything in Europe out of timber? The Stadthaus project required about 60 year's growth of a 3 hectare spruce forest (so 30,000m^2 of forest to produce 1850m^2 of living space). Gut feeling says no, it is not possible, but do the sums and there is potential to displace an awful lot of steel and concrete in construction. Concrete is currently our dominant engineering material (x10 by mass). It is about time that timber gave it a run for its money!