YEARBOOK 2019
SUPPORTING THE USE OF STRAW IN URBAN AND PUBLIC BUILDINGS

Interreg
EUROPEAN UNION
North-West Europe
UP STRAW
European Regional Development Fund

UP STRAW

FOREWORD

Dear reader,

This is the 2019 UP STRAW Yearbook.
This yearbook is the second of three to be published during the Interreg NWE funded UP STRAW project (2017-2020).

The theme of this yearbook is 'the straw experience to learn in' and aims to inform and inspire you about the application of straw as a building material in schools and educational buildings. In this document you can find articles that have been written by members of our project partners (France, United Kingdom, Belgium, Germany and the Netherlands).

In presenting this yearbook, we would like to thank all contributors. We wish you a good reading experience.

From the UP STRAW project partners

CONTENT

01 INTRODUCTION

UP STRAW is an Interreg-NWE funded program (2017-2020) in which French, Belgian, Dutch, United Kingdom and German partners cooperate. The aim is to position straw as the premium biobased building material, positively affecting healthy buildings, CO_2 reduction and environmental impact. UP STRAW stimulates and facilitates the application of straw in urban, public and private buildings.

Reducing the emissions of greenhouse gas CO_2 can make an important contribution to solving the global climate challenge. Approximately 36% of CO_2 emissions in Europe are caused by buildings. Reducing the energy consumption of existing buildings and constructing new buildings with CO_2 neutral or CO_2 negative building materials can make a major contribution to addressing this challenge.

Straw is an excellent insulation material that can be used in new buildings and also for the insulation of existing buildings. Straw is CO_2 negative (CO_2 is stored in straw during growth), widely available, fully recyclable and has a rapid growth cycle (annual harvest). In addition to the insulating quality of straw (it keeps the warmth inside), the heat buffer capacity is important. Summer heat (from outside) barely penetrates the interior, because straw buffers the heat. The effect is more comfort and less energy use for cooling.

Straw as an insulation material is often, together with clay, used in a vapour-open construction system. This creates a positive effect on the indoor climate. Because straw can be used without further processing and can be fully recycled, the total environmental impact is minimal.

Despite the positive effects of straw as a building material, it is applied on a very modest scale. In the UK, Belgium and the Netherlands (and also in other European countries) straw buildings are a small part of the total building production. In France there are about 5 000 buildings in straw but there is also a big opportunity for upscaling. Straw is -so far- mostly applied in a craftmanship production approach. The development of more industrial applications (prefabricated elements, blown-in straw) is recent. These techniques make straw more applicable in the existing concrete and brick- building industry.

The application of straw for insulating existing buildings is, as yet, hardly known. Straw as a building material is not included in building education programme in universities or professional training contexts. The general public is becoming more oriented towards healthy and environmentally-friendly living and building methods. Public buildings and schools can benefit from the positive effects of natural building materials. Especially in schools, the positive impact of biobased construction methods on an inner climate that facilitates learning is high.

02 EXPERIENCE: Notre-Dame de Bon Secours school (Belgium)

First school in Belgium insulated with straw

Interview with the Assistant Director of Notre-Dame du Bon Secours College

How did you come up with the idea of using straw in construction?

There was a lack of space in our school located in the city centre. We needed more space: a refectory, a multipurpose room and classrooms. At the time, work was planned in 3 phases spread over a period of 20 years.

It was during a wood trade show that I discovered the wood-straw construction modules, sold by the Walloon company Paille-Tech. The idea of working with several small modules, which go even further by being made of wood, seemed interesting, knowing that our school has a beautiful park.

We met several companies offering this type of solution, but many of them had their timber imported from Eastern countries. Our aim was to work with local companies, using local materials.

So, we chose to work with the Paille-Tech which had developed prefabricated modules as a solution for the Wallonia-Brussels Federation for adding classrooms to school. With a view to having a building that meets our needs perfectly, we worked with an architect who has mastered this construction technique, Christophe Looetvoet and the company De Graeve. The project appealed to the Board of Directors, which gave the go-ahead.

This is a first in Belgium. Are there problems associated with setting up such a project?

It has to be said that drafting the specifications has proven to be a long and laborious task. And for good reason, since this is the first school building to be insulated using straw. We have had to work hard with the General Secretariat of Catholic Education's architect. The company also needed to carry out expert appraisals and tests including fire resistance. Expertise and tests including fire resistance also had to be carried out by the company. The specification was approved three years and three versions later.

How did the construction phase unwind?

Very quickly. All the structural elements had been prefabricated in the workshop and so it took just 5 months for the building to be completed. The All Saints' public holiday was used for fitting out the interior. In addition to speed, the advantages of prefabrication are the cleanliness of the site, compliance with deadlines and little inconvenience to the neighbourhood. I also appreciated the fact that the pupils' work was not disrupted, in spite of the size of the construction site.

How was the building received?

The architect and a Paille-Tech staff member came to present the project to the pupils and the teaching staff. Everyone was rather curious at first. But our aim, beyond the environmentally-friendly building, was to make the young people aware of this aspect of the work.

How do the new premises differ from the old ones?

There is nothing quite like the impression you get when first entering these buildings. The pupils like the buildings a lot, and say so. The teaching staff

have also noticed that the environment in general is more pleasant in the new straw-insulated buildings. It has become a very quiet place and there is more of a Zen atmosphere.

Having been in the new premises for a year and a half, how does the building perform on a more technical level?

The building has a gas boiler that supplies two radiators per class. In winter, the temperature in the classrooms reaches 16°C without any heating. The fact that temperature variations are small is a huge advantage for a school building whose occupancy varies greatly. As a result of their exposure and the large, glazed surfaces, the first summer was too hot in 4 of the classrooms. The window coverings we put up solved this problem very simply.

With the premises being quite large, adjustments needed to be made in order to get the best sound qualities. In particular, due to the noise, dual flow ventilation has been set to operate only when the classrooms are not occupied.

The interior walls are made of clay which gives a great feeling of comfort but requires that pupils take care not to leaves marks on the walls.

Regarding maintenance, the management and the health & safety officer, as well as a teacher, the bursar and two workers, have all been given training in adjusting and programming the dual flow ventilation.

In just 3 words, how would you describe this building?

Comfortable, bright, economic.

03 EXPERIENCE: Victor Schoelcher Nursery school (France)

Passivhaus certified / Winner Wood Trophies

Article written by Fabienne Pasquier (CNCP-Feuillette), in collaboration with Corentin Desmichelle (Atelier Desmichelle).

This nursery school, opened in 2016, has 5 classes and an after-school facility. The use of natural, passive and biosourced materials was proposed by the architects during the competition stage. The emphasis throughout design and construction has been on the use of natural materials and techniques by building a wooden frame, straw insulation and a green roof. These choices have allowed the school to be well insulated from urban noise and disturbance.

Located in an urban setting amongst houses in the district, the compact size of the school building allows maximum space for the garden. The conservation of existing trees and plants is a reminder of previous uses of this location as a public square.

The functionality, the design that maximises solar gain and the mechanics of walls and floors were planned together to optimize materials and fluidity of movement. The objective is to give preference to indoor comfort in all seasons, with heating requirements not exceeding 15 kWh/m^2/year.

The role of wood (Douglas Fir from Normandy) in the design and construction brings multiple benefits: protection of the facades without the need for maintenance, reduction of structural thermal bridges and a friendly and aesthetic environment. The choice of straw (from Loir-et-Cher) gives 40 cm of depth in the wooden frame structure and enables optimal thermal and acoustic comfort.

The building is orientated to the south and benefits from a dual-flow air renewal system with high heat recovery efficiency. On average, 3 000 m^3 of new air is regenerated each hour. Wooden/aluminium windows with triple glazing and swivelling blinds contribute to inertia and thermal insulation.

The wood/concrete composite floor reduces structural thermal bridges whilst improving acoustic insulation and interior aesthetics.

The green roof is covered with grasses, lichens and flowery meadow plants, which absorb large amounts of water in their stems and roots. This doubles the sealing of the roof and contributes to the insulation of the entire building.

Technical context:

- Delivery: September 2016 // Cost of HT works: €2.1 million // Floor area: 953 m^2
- Nursery school of 5 classes, with leisure centre, motor skills activity room and school dining room for 95 children (in the beginning of 2016).
- PassivHaus certification, as proposed in the competition.
- Objective: simplicity and compactness of the project.
- PHPP software used to verify design.
- Complementarity of passivHaus principles with the integration of low-energy materials (wood and straw).
- Urban continuity with adjoining buildings and alignment to the street.
- Harmony of extended gardens with courtyard and green roof meadow.
- Extensive use of wood: fence and cladding (Douglas Fir) on the exterior and rendered from the underside of the slabs on the interior (visible staggered joist).
- Central position of a motor room (more than 100 m^2) on the ground floor: passage of the networks, in a central sheath, to the floor so as not to cut this volume and avoid false ceilings.

- Need for accurate synthesised work throughout construction process.
- Allocation in macro-lots, covered by CBS-Lifteam (design office, prefabrication, construction).
- Covered and protected in 1 month, for a 9-month construction period (January to September).
- Project execution: control office not prepared (need to increase meetings) but strong support from the owner.
- Few reservations expressed at initial reception of design ideas.
- Cost per m² equivalent to other less energy efficient materials and equipment.

Technical information:

Estimated heating consumption 15 kWh/(m².an) // target Passiv Haus
Air tightness: n_{50} = 0.47 vol.h-1// Passiv Haus target 0.6

<u>Lots constructed by wooden materials:</u>

- Structure (post/beam, frame, wood and mixed wood-concrete/softwood); casing (exterior joinery // larch; cladding // douglas fir); interior and exterior fittings.
- Ratio of wood (structure, cladding and partitioning, excluding panels): 278 dm³/ m² SP // Equivalence Charter wood construction public exemplary (Île-de-France): Exemplary
  - Volume of straw (insulation, wood frame filling): 147 m³ (between 1,000 and 1,100 small bales).
  - MOB frame (filling straw bales, from Loir-et-Cher).
    - Slab system for long range
    - Roof: O'Portune Slab – Scope 11.7m
- Floor to floor: D-dale, (O'portune slab, connected to concrete screed) – 9.1m scope.
- Insulation: straw bale (walls); polystyrene (roof and low floor). Selection of the PSE roof for a question of weight (in relation to straw and scope length).
- Air tightness: main surface treated in the workshop : tight frame boxes + on-site fittings (vapour barrier membranes and adhesives).
- Acoustic: controlled by the relief of the slabs (without false ceiling), and acoustic reduction thanks to straw with lining and rain guard (between 43 and 45 dB).
- Thermal: solar gains and double flow thanks to the air handling unit (+ gas-fired condensing boiler).
- Summer comfort: sunscreens (exterior blinds) and option of ventilation at night.

04 EXPERIENCE: Educational institution Emmanuel d'Alzon (France)

School and college on 2 floors

Interview with
Sébastien Girardeau
(Dauphins architecture)

Having looked at your work and achievements since 2007, I noted an emphasis on biosourced projects and working in partnerships. How would you describe the agency today?

For each project, living is at the heart of our thinking. In architecture, this is manifested by how people use places - the anthropogenic character of architecture. We explore topics such as freedom, flexibility, historical and cultural context, symbolic figures of architecture as well as landscape.

We work in participatory ways as life is also represented in the fauna and flora that inhabit spaces. We have an interest in greening the building by finding refuges for biodiversity and integrating the landscape.

The use of environmentally friendly and healthy materials, and bio-climatic design bring real comfort and reduce energy consumption, while respecting the surrounding environment.

In my opinion, the agency's position articulates these different concepts; the ultimate objective being to strive for a sustainable and ecological common good.

I have just visited the Alzon site. What is 'the story to be shaped' here by the architect?

We are in a future place of learning. The aim is to provide a place for educational opportunities. The pedagogy of the future school is part of a singular approach to national education standards. From this point of view, 'the story to be shaped' is to let this educational project grow.

What have been or are the main constraints of this site?

The site itself was a first constraint because it is marked by a wetland. We have preserved it in the project and proposed it as a place of pedagogy, to be included in the construction of the school. It could be an ecological classroom, with rainwater recovery, composting, vegetable gardens etc. The wetland is a real issue because it limits space, which reduces storage and site access and potential for flooding brings additional complexities.

Another major constraint is time and the pace is set by the start of classes when the school re-opens.

Who made the choice of wood/straw biosourced materials?

The choice of materials like straw and wood fibre insulation and the wooden structure was formalised by the project management team during the competition phase. These materials contribute to the project identity and the inauguration of the site was symbolized by the laying of the first straw bale. I believe sustainable materials echo the institution's pedagogy and values.

When and how do you imagine users will take ownership of the site?

The first students arrived back in September 2019, on one part of the site, while construction work continues on the other side. It is difficult to imagine how users will appropriate the place. What is certain, and very interesting, is that we can observe how students and teachers will use classrooms and other areas while construction work is ongoing.

Can the construction work be modified before completion?

The sides of the teaching buildings have been designed to allow modification of internal distribution, thus guaranteeing flexibility of the frame and uses. The wooden floors are supported by the façades, thus freeing interior space. Moreover, flexibility of design allows us to modify certain partitions, thereby linking several rooms together.

In terms of interior comfort, what principles were used for heating and ventilation? Can you tell us some of the technical elements involved ?

For comfort, the first focus is on passive systems which don't require energy to operate. Straw provides excellent thermal insulation, which protects against cold in winter and heat in summer. The orientation of the buildings, the position of windows and blinds benefit from solar gain in winter while protecting against overheating in summer.

A passive natural ventilation system allows air to be renewed for a large part of the year. In winter, a double-flow mechanical system preheats incoming air. It is therefore a natural/double flow water ventilation system.

A biomass boiler provides additional heating in winter.

On this project, what are the rules, standards and boundaries that you will question?

Most of the project's facades are made of straw-insulated wood frame, the floors are also made of wood. The implementation of straw had to be justified from a regulatory point of view because no reference framework exists in the case of an ERP second category in R+2, which was a real challenge, both in design and construction.

There are professional rules of straw construction*, but here we reach its limits.

We conducted laboratory fire tests in which a 1:1 scale model was set alight - the objective being to ensure that flames were not transmitted to the floor for the first 30 minutes. The results were excellent so we went further and after 60 minutes the flames still had not reached the floor. To give an order of magnitude, ten times more thermocouples (around 150) than for a conventional test were arranged in the model to measure the temperature variations inside and understand the diffusion of heat and flames in an isolated wall of straw.

How do you see the future of bio-sourced and natural materials in construction?

There is a growing demand from contractors to integrate these materials into future constructions. The main obstacles remain those of regulations which, despite everything, are still slow to incorporate their use. However, things are moving in the right direction for the regulation of natural materials. This is good because the construction industry is one of the most damaging sectors of activity on the environment.

Is St Médard a blessed building site?

The first straw bale was blessed by Monsignor Ricard, having been asked by the Mayor of Saint-Médard-en-Jalles, Mr Mangon. We hope that this symbolic gesture will bring us to the successful completion of the building.

* French rules of straw construction: 'Règles professionnelles de la construction en paille CP 2012 révisées' – Edition Le Moniteur

05 EXPERIENCE: Hauxley Wildlife Discovery Centre (United Kingdom)

Learning comes naturally

Located in a spectacular position on the Northumberland coast in the north of England, Hauxley Wildlife Discovery Centre is an award winning example of a public building made from straw and other natural materials. It is an exceptional place in which to learn about the natural world and to watch wildlife.

The original education and visitor centre was destroyed by fire in June 2010 and resulted in subsequent demolition. Undaunted by this, the Northumberland Wildlife Trust set about building a new visitor centre and transforming the whole reserve, which re-opened to the public in June 2017, almost seven years to the date it burned down. The reserve was originally an open-cast coal mine and was purchased by the Trust in 1983.

Designed to high standards of sustainability by local architects Brightblue Studio and built by an army of dedicated volunteers over 26 000 hours, Hauxley Discovery Centre was made possible by a grant of £522 600 from the UK Heritage Lottery Fund.

As well as its construction, the running of the building has been considered from a sustainability point of view with a biomass boiler as the primary heating source and rainwater harvesting for grey water needs.

The construction team overcame a number of practical issues, which demonstrated their flexibility and problem solving abilities. Mining risk subsidence issues were dealt with through geogrid layers as part of the foundation design, to prevent movement.

The architect, Henry Amos, was inspired by the setting of the building and knew immediately that natural materials would be the only appropriate medium. From his perspective, the challenge was to build a building with mostly volunteer labour intended to be the 'greenest' and most sustainable building in the north east and nationally an exemplary building. At the same time, the intention was for a building that cost significantly less than a similar building to construct and subsequently run.

His intentions in the design of the building were that as visitors went through the entrance the Centre would 'breathe' and open up in natural and welcoming ways. In line with Hauxley's wildlife focus, he designed the building to have two 'wings' which are clearly visible from certain perspectives. In the same context, he wanted the building to 'nestle' in the landscape rather than dominate its surroundings. Accompanying images show how he has achieved these aims.

Architect Robert Venturi takes a political view and provides important insights into the ways in which public buildings are valued. 'Architecture obviously reflects what a society holds important, what it values both spiritually and in terms of cash. In the pre-industrial past the major areas for expression were the temple, the church, the palace, agora, meeting house, country house and city hall; while in the present, extra money is spent on hotels, restaurants and all those commercial building types I have mentioned. Public housing and buildings expressing the local community or the public realm receive the cutbacks. Buildings representing consumer values generate the investment.' (from 'Architecture as Signs and Systems', 2004).

Education and learning about wildlife, conservation and related topics are central to the work in Hauxley. A straw bale classroom is prominently positioned in one of the 'wings' of the building and is extensively used by a wide variety of educational groups and trainers. Topics include what one might expect, such as bird watching, seal conservation, red squirrel protection and wildflower identification. However, staff have been pleased to discover that the straw bale classroom is also popular for painting, printing and collage workshops.

It has also proven very appropriate for a Mindfulness and Meditation group who welcome the inner air quality, silence and stillness the straw bale classroom provides. The architect Charles Jencks explores ways in which architecture can overcome 'the historical dichotomies of body/mind and matter/spirit…that brings together these opposites into a comprehensive unity.' (From 'Architecture 2000'). As one member of the Hauxley team says: 'Many teachers and learners have commented positively on the warmth, comfort and stillness of the classroom.'

Hauxley Wildlife Discovery Centre was the regional winner of the Best Public Service Building category of the LABC (Local Authority Building Control) Northern Building Excellence Awards in 2018. This Award followed on from its first prize in the Community Category of the annual Royal Institute of Chartered Surveyors (RICS) 2018 Awards, North East in April and securing three first prizes: Regional Award, Sustainability Award and Best Client Award in the Royal Institute of British Architects (RIBA) North East Awards 2018.

06 EXPERIENCE: Green Woodpeckers peck on straw (Germany)

Carpenters convinced after first pilot project

Interview with Markus Wolf, carpenter and member of the board of the timber construction company.

The carpentry company Grünspechte e.G. has 44 employees and is committed to ecology, healthier building and sustainability. It has constructed well over a hundred residential units as single-family and terraced houses, as well as multi-family houses, extensions and annexes.

Since October 2019, the 'Green Woodpeckers' have been building their first straw-insulated building: eight residential units near Freiburg, which are prefabricated in the company's factory. Markus Wolf reports on the first straw building experiences, highlights and challenges as well as why it makes entrepreneurial sense to build sustainably.

Markus, why did you decide to get involved in straw construction even though your order books were full?

We at Grünspechte are an ecologically minded workforce and global issues are very important to us. For many of the world's challenges, such as climate change, scarcity of housing and resources, straw-building offers answers. We are pioneers in the building sector and want to change current construction industry standards in the direction of more sustainable construction. For some years now we have been looking for an even more ecological construction method, a new unique selling point. So we came to straw and clay. When a client showed interest in it, we got involved in the topic and decided to start the pilot project with this client.

And what are your first experiences with straw bale building?

First of all, straw is a sympathetic construction product. We only get positive reactions to this building method from outsiders. Our entry into the straw construction scene was great. Networking with enthusiastic people who want to make a difference is very fulfilling.

What's also very motivating is that even though the materials used in straw construction are more labour-intensive, the handling of them is more satisfying because you can add more value with a smaller variety of products. Compared to industrial building materials, straw building products are simpler and cheaper. The customer pays his money to the craftspeople for their work and not to the building materials industry.

Another thing that convinces us about modern straw bale building is that the construction method is very sophisticated. Straw insulated buildings are particularly sustainable and at the same time on the highest technical and design levels. That's what customers want nowadays.

Which technical approaches have been supportive for you?

We are used to working with a high degree of prefabrication and, for this approach, straw bale building is highly suitable. We build the wall elements in the workshop and are therefore protected from the weather for a long time. In the carpentry work, we can use our technical infrastructure and fill the walls with the bales in situ, which is much easier than on-site installation.

Our good fortune was that we found a straw supplier who could produce a special bale format. The manufacturer received from us a straw list with the dimensions for all compartments and adapted the bales to our wood construction plan. Due to the individual straw bale production and the quadruple lacing, we can install the bales relatively easily. It also ensures that we are flexible in

design and execution and that the individuality of the design is not constrained by the construction method. That was important to us.

You should pay attention to the weights, the deformations and the payloads on the large, insulated walls. The walls must not be too heavy for the crane and they must not be deformed by the load.

It is also important to think through the static solutions with regard to the stiffener early with the structural engineer, because in straw bale houses there might be other solutions for stiffening than an OSB plate.

What were other challenges that you faced in your pilot project?

Logistics are a challenge: with limited company sizes, the storage of straw and the prefabricated walls must be clarified in advance. Our solution was an external storage platform that served as a warehouse for the straw outside the factory. The cost of that storage has to be calculated in advance. And straw bale building creates a fair amount of debris in the workshop.

What would it take for more carpenters to learn to build with straw?

Awareness of the potential should be higher so that the demand arises.

CO_2 emissions should be priced into the cost of construction materials. Then straw bale building would be financially very attractive, as CO_2 is contained in straw during growth.

Carpentry companies, who look for skilled workers, need to be aware that building sustainably can bring competitive advantages in the labour market. Certain young and motivated construction professionals do not just want to have a job but a task that makes sense to the world and fits for the future. Besides the wish to earn good money, this can be an incentive for applying to a carpentry company that specializes in sustainable building.

With straw bale building, we have taken a new path after 35 years of company history and found a new unique selling proposition. We are happy about it and hope for the sake of our planet that we will not stay so 'unique' for too long. Straw bale building is ready for the market and can already be applied by all construction professionals and private as well as public builders.

07 EXPERIENCE: Passing on the torch of straw bale building (Austria/Germany)

Students learning by building their study room with straw

Interview with Virko Kade of One Straw Revolution, a construction practitioner and consultant for sustainable, experimental and ecological building.

After years of building straw-insulated houses as a building contractor, he now teaches straw bale construction at the University of Applied Sciences Salzburg in the course 'Smart Building'. Virko also offers straw building seminars on the open market for building professionals and laypeople. One of his specialisms is load-bearing construction. In the following interview he talks about his courses, about the advantages of load-bearing construction and how construction professionals benefit from working with it.

ADVANTAGES OF LOAD-BEARING CONSTRUCTION

- It is a building method that is very fast and easy to learn.
- It is absolutely resource-saving through minimal use of industrial building materials.
- It is cost-effective.
- The building physics function of straw is permanent. It works without film and tapes.
- It has great creative potential in design and wall courses.
- It is well suited for communal building.

DISADVANTAGES OF LOAD-BEARING CONSTRUCTION

- In Austria and Germany there is no easy approval procedure. Comprehensive evidence for a construction supervisory approval is lacking so far.
- Rain during the construction phase is more problematic than with wooden stud structures because the roof is constructed in a later phase.
- Hanging heavy objects on walls can be somewhat limited.

Virko, what makes you enthusiastic about straw bale building?

I am impressed by and enthusiastic about the simplicity of the construction method and of straw bales as a material. At the same time, straw can be used in a variety of ways: bales of straw in the construction sector serve as insulation, as a plaster base and as a static element. Another important argument for straw is its transparency of origin and production. Ideally it comes from the field next door!

Load-bearing construction is the original method of building, which is over 100 years old and was rediscovered in the 1980s. In load-bearing construction, we achieve the simplest wall construction available. Here, the whole potential of straw as a building material can be fully experienced. Anyone who has built load-bearing walls gains a deep understanding of the material and can better understand other construction methods.

In some of your seminars, the participants build their own training room from bales of straw. Why do you do this?

The practical experience of straw bale building is very convincing. When we build a load-bearing structure ourselves, room quality, acoustics and sound insulation are directly understandable. The strength of the finished walls is astonishing for workshop participants. Only then does it become believable that straw bale building actually works. There is always a 'magical moment', when the completely loose straw bales are fixed with ring anchors and straps so that from one moment to the next a stable wall structure is created.

What changes do you observe in the students when they have their lessons in the straw-insulated room?

They seem much more relaxed and most people also report that they feel relaxed as soon as they enter the room. The sense of space, acoustics and the room climate affect deeper layers of consciousness. In addition, electromagnetic radiation is shielded. Depending on the window surface and orientation of the house, mobile phones sometimes do not work at all. I have often heard that radiation-sensitive people experience relief.

Why should students of architecture and construction also learn about straw bale building in their general education? What's in it for them?

They can expand their horizons about possible construction methods and learn that you do not need any industrial building materials for ecological quality construction.

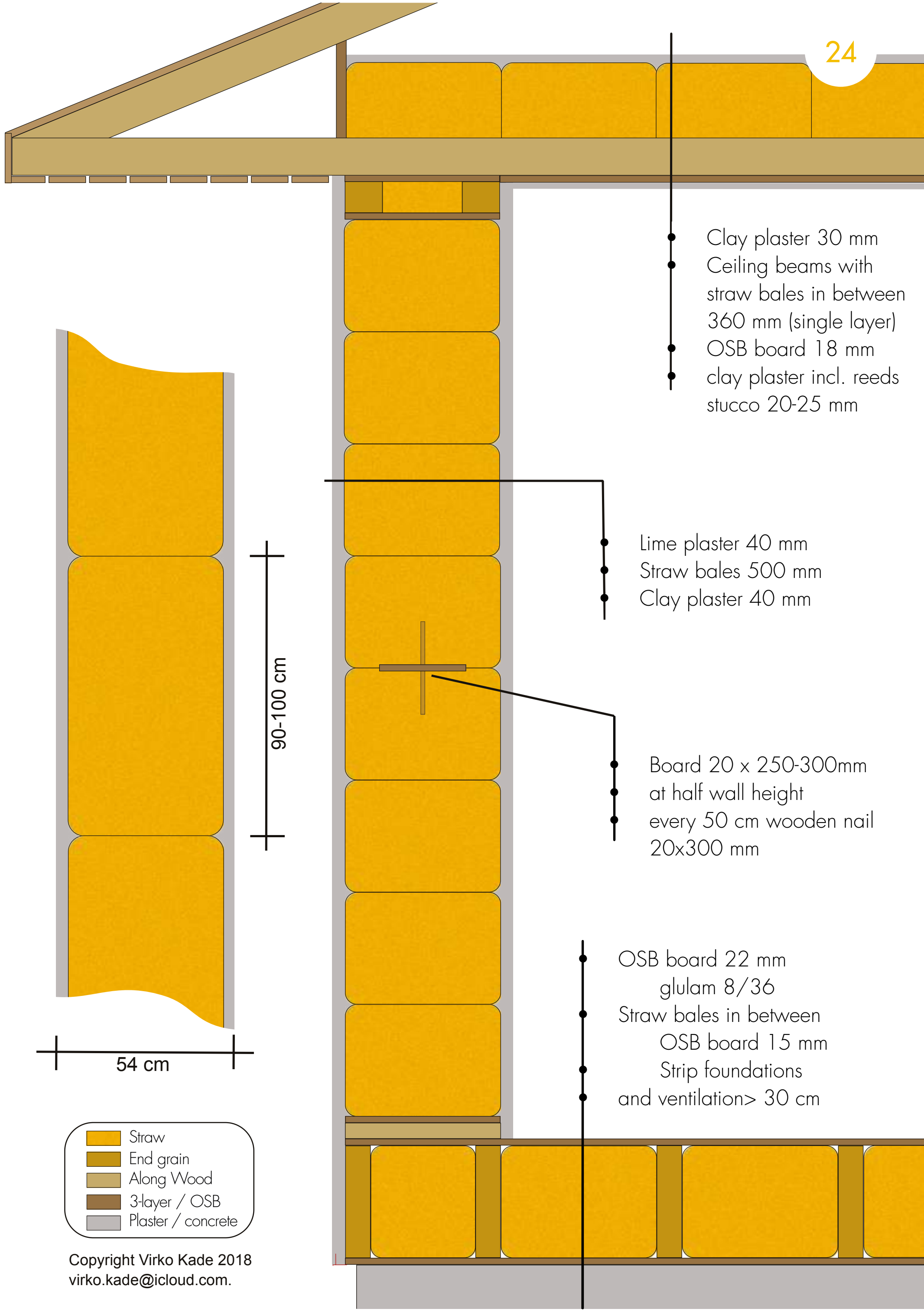
The students also get a very different sense of static, because they can see and understand static behaviour directly in this building material.

And they learn that it is possible to achieve modern comfort with a traditional construction method and to comply with construction law requirements.

Anyone who learns straw bale building in theory and practice should also learn how to plaster. Only then will students know how to leave a straw wall so that the plasterers can then do their job well.

Who is suitable for learning straw bale building?

People who enjoy the experience and understanding of building materials can benefit greatly from a straw building seminar. If you want to work professionally with straw bales, you need a certain amount of physical fitness. The bales are 12 to 20 kg heavy (26 to 44 pounds) and building with them uses the wrists a great deal. But generally speaking, a training in straw bale building is instructive for everybody.



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08 EXPERIENCE: Roomley sports hall (Netherlands)

Renovation of a sports hall with blown-in straw

International partnerships

The municipality of Tilburg was very pleased to be invited by the National Straw Building Association of the Netherlands (SBN) to join an international project to pilot the use of straw in the renovation of an urban building.

In the past Tilburg had developed a tool to evaluate procurement that would achieve a combination of 'energy, environment, health, quality, future use'. With this tool, the focus shifts from 'lowest price' towards other aspects and can thereby gain higher results in sustainability. During the initial phase of UP STRAW, Tilburg was already progressing their own roadmap towards sustainable asset management. In this context, the municipality of Tilburg quickly became a strong and proactive partner in UP STRAW.

Renovating with straw to improve insulation

Tilburg and SBN evaluated different buildings where the use of straw could be combined with a planned mid-life upgrade. The Roomley Sports Hall in Udenhout appeared to be a good option for a pilot renovation with straw. A sports hall or gym is an exemplary building: in the Netherlands you can find hundreds of this kind of building. Many were constructed in the 1970s and '80s, with very limited insulation. They are used all year round, with high heating costs in the winter and hot indoor climate during the summer.

Project evolution

The first idea for the renovation was wrapping the existing building with straw to create an indoor climate that would be comfortable, with low energy usage for heating and cooling. However, during the first evaluation, it became clear that a significant upgrade of the envelope of the building alone would not be realistic for a building more than 40 years old. There should be more than only an extra skin of straw since all the interior and installations were in need of a mid-life upgrade.

The renovation plan evolved into a project where only the two sport-halls would be kept. All the other parts of the building would be removed and a new extension made at one side of the remaining halls. With this plan a more compact building would be created wherein the existing halls are wrapped with straw and the new extension has an elevation of straw.

Combination

With this plan for the renovation of The Roomley Sport Hall, there are two different uses of straw: the existing parts wrapped with straw and the new extension closed with straw. The combination of 2 basic areas for the use of straw was inspirational in the search for applications where new-build and renovation provide a good match.

Learning from the past

Finding solutions that could support the design process for the new straw walls of Roomley we looked at several exemplary straw projects from the recent past.

- Germany: existing building covered with strawbales fixed with special supports.
- France: existing steel structure closed with elements filled with straw.

- France: new building made of CLT insulated with elements filled with straw.
- Swiss: existing office wrapped with building-high elements of straw.
- United Kingdom: new concrete structure wrapped by building high panels with straw.
- Austria: strawbales made at the right size to fit the construction or straw cut into small particles that are blown inside the cavity of a construction.

Tilburg chose blown-in straw

Once all the options for renovation had been evaluated, it was decided the use of blown-in straw would provide the best solution for the Tilburg situation:

- no straw bale handling on site.
- dimension of straw elements freely chosen, based on requirements.
- low impact on the building process for partners.
- can be copied to any other renovation project.
- refers to previously known techniques such as blown-in cellulose, woodfibre and more.

Combined with the need to close off new areas that had no wall in the original building, it was decided to make prefabricated straw elements with an inner and outer board, and not use the existing wall parts to close in the straw. These prefabricated elements are made and filled with straw at a factory near Tilburg.

Looking forward

By the end of November 2019, the prefabricated straw elements were installed on the rear wall. By early December, the remaining elements were filled with straw at the factory of Barli in Uden.

In January of 2020 these elements were mounted on site. The renovated Sports Hall is scheduled for opening in May 2020.

This will complete the first public building with blown-in straw in the Netherlands and possibly the largest building with blown-in straw in the world at the moment. But it is not about size, it is also about setting an example for others. In fact, we hope this record will be broken a few times, every year from now on!

The use of straw for insulation needs no complex industrial processing and the energy needed to give the required performance for more than 100 years is very, very small. The end-of-life scenario is very simple: make a hole, remove the straw and re-use it for the next 100 years in another building without the need for re-processing. There's no need to worry about a lack of straw; because it is simply a grass, just like rice, reed or miscanthus.

And keep in mind: every ton of straw is equal to one-and-a-half tons of CO_2 so that, in effect, you are building with air.

09 TECHNICAL ARTICLE: School inner climate (France)

What is comfort?

The notion of comfort is a concept with a variable parameter that requires us to specify the context. For example, we can talk about the hygrothermal comfort that will be related to the impact of temperature and humidity inside a space and its effect on the feeling and the well-being of a user. One can also speak of the visual comfort, a highly subjective parameter, which will be related to the aesthetic appreciation of the neighbouring spaces, the luminosity or the appropriateness of the colors among others. Not to mention the acoustic comfort that will be linked to both external disturbances (such as a busy road) and internal disturbances such as ventilation or a cracking floor.

These nuisances will be even more important unless the nature of the materials will mitigate and isolate them. Also, the nature of the walls will reduce the resonance effect and promote clear listening of conversations without much effort.

The case of schools

The challenge for schools of the future is to accommodate an ever-increasing population. The population is growing and must preserve its resources. Ambitious schools must use the most virtuous practices including in their design. Children must also benefit from the best standards in terms of cultural evolution, education and living environment.

Straw provides solutions

With an unbeatable environmental footprint and high performance, straw stands out as the reference material in schools of the future. Indeed, as a building material and insulation, straw is currently the solution with the lowest environmental impact and greatest availability at European level.
Today, scientifically recognized and widely recognized, the multiple performance of straw explains the excellent comfort and low cost of operation of these buildings.

Optimum conditions for learning

Top performance is good in understanding their results is better.

The temperature remains stable around 21° summer and winter with very small variations depending on occupancy rates and the opening of doors and windows. This reduces the physical fatigue produced by the need for regulation of the body. With indoor earth plaster, the humidity rate stabilizes around 60% which represents the physiological ideal for the human being. This ensures a comfortable feeling while reducing the risk of mould growth, bacteria, air drying and dust circulation.
'Wooden frames and interior finishes can produce odours that affect well-being and heart rate. By using natural materials, children's concentration levels can improve.

The major drawback

The children will feel so well in school that they won't go back home.
This will encourage parents to consider this type of construction.

10 TECHNICAL ARTICLE: Wrapping technique (France)

Wrapping consists of isolating the walls of buildings with a layer of straw on the outer walls. The straw can be blown-in, chopped into boxes, or integrated into a wooden frame or boxes filled with straw bales. This technique can be used on any type of building, in any climate.

A technique full of strengths

This insulation technique has many advantages. First, by insulating the walls from the outside, it preserves the inertia of the masonry to stabilize the atmosphere inside the building. In general, whether in older or more recent constructions, this technique also reduces the risk of moisture-related disorders in the walls. The added value of the straw material is:

- a good thermal stability which improves summer comfort.
- a surface for the coatings allows greater architectural freedom.
- an abundant resource for insulating buildings without exhausting the planet resources.
- an ability to store and reduce CO_2 while promoting energy saving.
- good thermal insulation for energy savings and controlled temperatures.

Knowledge of the technique

The use of bale to insulate a building from the outside requires the acquisition of specific knowledge to guarantee optimum results.

Straw is a material with very different characteristics of the products generally used for this kind of service, it is therefore essential to acquire appropriate skills and experience.

Some precautions to take

As straw is a natural material, like the majority of biobased material, it is necessary to protect it from water and moisture in general. For example, care should be taken to install rot-proof and water-resistant lining to a sufficient height before starting the straw insulation.

For building owners, the innovative nature of this practice requires verifying the skills of the companies that will design and carry out the work. To do this, make contact with your straw construction network.

11 TECHNICAL ARTICLE: **Prefabricated technique** (United Kingdom)

Straw Panels and UK Schools

Prefabricated straw bale construction systems use a natural, low carbon, renewable product, providing high levels of thermal insulation. This modular approach appeals to the creative side of architects and can make life much easier for builders.

ModCell® is an example of a UK system that uses these excellent thermal insulation qualities of straw and timber to make prefabricated straw panels for schools and other buildings.

Schools built using prefabricated straw bale panels are designed to meet the exact needs of each school, providing spaces and relationships that meet curriculum and functional requirements. They also meet Building Bulletin guidance in creative ways, and anticipate increases in Building Regulation standards.

The material palette and construction method enable teaching and learning opportunities to be integrated into the design and construction process, providing important added value for students and the wider community. Additional benefits of this process include: quick and efficient installation on site; excellent quality control; cost savings due to reduced construction time; waste reduction; involvement and ownership by the local community. They use local labour to deliver a high quality, modern method of construction, reducing the negative impacts of building on the environment. The prefabricated panels are constructed in what they call a temporary

‘Flying Factory™’, which can be located within ten miles of the construction site.

Technical Details

A common misconception about straw buildings is that fire and moisture pose particular risks. ModCell® lime rendered panels have a fire rating of over 2 hours and have been subjected to accelerated weathering tests and a range of structural and performance tests at the BRE’s Centre for Innovation in Construction Materials at Bath University.

ModCell® Core panels are available in a range of depths:

Panel depth	Straw depth
427 mm	400 mm
377 mm	350 mm
262 mm	235 mm

ModCell® Core at the above depths are plus the depth of the battens and depth of cladding. The battens and surface finish could be on both the internal and external surfaces.

ModCell® Core panels 427 mm, 377 mm and 262 mm are factory finished fully closed, dry lined panel system using breathable sheathing boards and breather boards. The standard external finish is breathable sheathing board, battened ready to receive a variety of rain screen cladding systems. The internal sheathing board is ready to accept a variety of internal boards.

The straw bale panels can be lifted into position on site using a telescopic arm or crane. The mass of 2.7 m x 3 m ModCell® panel is approximately 750 kg. Panels are sealed using a range of airtight tapes.

ModCell® u Value data

Panel depth	Straw depth	U-value
427 mm	400 mm	0.13 W/(m²K)
377 mm	350 mm	0.14 W/(m²K)
262 mm	235 mm	0.19 W/(m²K)

PassivHaus

The ModCell® Core + System delivers on the demanding PassivHaus specification requirements for U-values, air-tightness and thermal bridging.

PassivHaus projects combine the excellent performance of ModCell® with improved glazing specification, Mechanical Ventilation Heat Recovery (MVHR) and project and location specific design.

Sequestered Carbon

1 m^3 of ModCell® Core 427 mm panels has 145 kg of atmospheric CO_2.
Typycal 100 m^2 GIFA BaleHaus 43 tonnes of atmospheric CO_2.

Fire Performance

ModCell® Core 427 mm = 1hr+
ModCell® Core 377 mm = 1hr+
ModCell® Core 262 mm = 1hr+

Acoustics - sound reduction

ModCell® Core 427 mm = 41 - 49 RW(-1, -3)
ModCell® Core 377 mm = 41 - 49 RW(-1, -3)
ModCell® Core 262 mm = 41 - 49 RW(-1, -3)
Higher 41 - 49 RW values include the use of 12mm of Fermacell board as internal surface finish.

Case Study: Castle Park Primary School

Castle Park School is in Monmouthshire, Wales and provides education for children from age 4 to 11 years. The brief was to extend the school with a ‘learning plaza’ for 60 pupils. The school itself and Monmouthshire Council requested sustainable and innovative technologies which deliberately contrast with those of the existing school.

The plaza is linked to the main building at existing levels with main access via the existing school entrance. Within the Plaza, the space is divided into a number of zones for group work, presentation and performance, art and science areas. In addition there is a quiet pod space, two cloak areas, internal and external storage.

The elevations are predominantly a mix of large lime rendered straw bale panels, framed by timber cladding and sitting on a brick plinth. Full height glazing punctuates the panels on the northeast elevation (fronting the external teaching space), offering direct access to the outside environment.

School staff, pupils and councillors visited the Flying Factory™ which was situated in a nearby farm, for a day out to see the straw bale panels being made.

The building design adopts a 'passive first' approach to sustainability. In essence, the building fabric acts as a moderator of the external climate and the heating, ventilation and lighting installations deal with the reduced demands of the moderated internal climate.

Natural light is maximised and windows and roof lights are designed and positioned to distribute daylight effectively, carefully managing any unwanted solar gain during the summer.

Colour contrast is used in the classrooms as much as possible so that partially sighted learners can more easily orientate themselves within, and navigate their way to the facilities within the building. Tonal contrast was considered in the selection of door leaves, frames, architraves and door furniture, to facilitate use by the partially sighted. A sound absorbing ceiling is used throughout, so as to gain improvements in hearing and understanding. All the selected materials help to reduce sound reverberation within the building.

12 TECHNICAL ARTICLE: **Blown-in straw for renovation** (Netherlands)

Straw building techniques that use straw bales will, inevitably, give a minimal wall thickness related to the bale size. In the sports hall renovation project at Tilburg, with 1 000 m² wall, this could lead to higher costs and performance than required. An Austrian farmer (Sonnenklee) was making modifications to an existing baling machine that would produce straw bales at the required size. This could be the solution to building a wall of the correct thickness. However, when informed about the bale sizes, we also learned they were producing straw to be blown in. With blown-in straw the wall dimensions are much freer and more customisable than with bales.

We visited Sonnenklee to learn about the customised baling machine and the blown-in straw. This visit was combined with a one-day course on blown-in straw at ISO-Stroh. They started using blown-in straw some years ago by developing a machine to produce a very good type of blown-in straw. Learning by doing.

Blown-in straw is applied in rigid, form-stable and loadable cavities. For a vertical application and for roofs steeper than 45-deg, the maximum recommended height is 3 m. The maximum width of a cavity is 75 cm.

Inspired by the possibilities of blown-in straw for the renovation of the Roomley Sports Hall at Tilburg a sample construction was made with a height and thickness that corresponds to the basic ideas for this project. This test box was also equipped with two small windows, and some internal obstructions, to check the impact of these features.

The weight and volume of the box were measured to calculate the blown-in density (62,8 kg, 0,393 m^3). We ordered a pallet of Sonnenklee blown-in straw and, with the assistance of Ekoplus and a EM325-X-floc machine, some tests were conducted.

Density:

After some adustments and testing, the correct settings for the EM325 were found and we could fill the test box with straw.

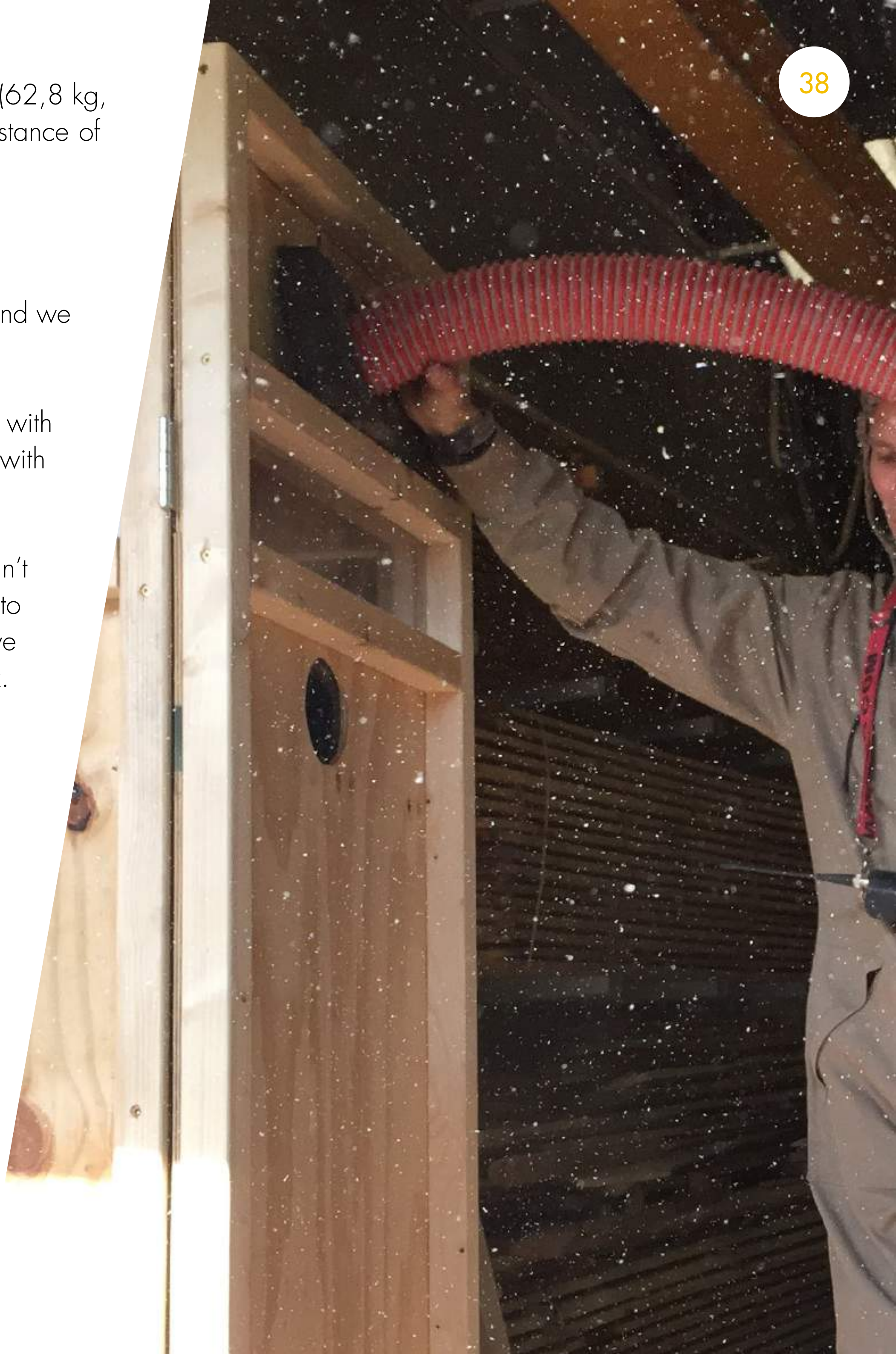
First, the density of the blown-in straw had to be determined. The test box was filled with a hose in a vertical position. After opening the box, the result was clearly visible: with equal density and no spots with lower values, we had a good result.

We tried to sample the density with a cellulose measuring device but this device didn't work with straw. After measuring the weight of the filled sample-box we were able to calculate the overall density (42 kg for 0,393 m^3 = 107 kg/m^3). In another test, we tried to fill the sample box with an opening some distance from the top of the box. This was not succesful during the first tests.

Local straw request

Linked to the project requirements to use local straw, we also looked for other types of small straw. A first test with chopped straw 1-3 cm from the Netherlands was not successful. There were too many particles of the same length and the 3 cm length caused 'bridges' during filling.

A local producer of straw products looked at our test results and straw samples. He could not produce what looked like the best option but his advice was that with straw from a partner-firm we could have better results. This straw was ordered and we conducted several tests with promising results. There was no settling of the blown-in straw during transport with density above the 105 kg/m^3 and we could even reach densities of more than 125 kg/m^3 without additional equipment.



By that time ISO-Stroh had carried out their first cooperative tests with a German producer of blowing equipment, X-floc and they did a speed test on their straw, reaching more than 12 m^3 per hour. By estimating about 10 m^3 per hour as the maximum speed for local straw, we could estimate the time needed to fulfil the Tilburg project. When we added all the handling time at 50%, we could fill the straw, with 2 machines, at a rate of 10 m^3 per hour.

Detailed design for blown-in straw

Using straw for renovation of the outside of a building gives the best starting point in terms of building physics. The basic idea was to use the existing outer wall, fix vertical beams on the wall and close the cavities with a vapour open board and blow in the straw.

This was also tested on site: because the existing wall was not very straight, two options were tested. In one test, the small gaps between the existing brick and new wood structure were left open and in the other option they were closed with some insulation. During the filling of the straw, it was clear that the small gaps between the brick surface and wood construction had no negative effect on the process of blowing in the straw. In fact, a compartment with some air leakage gives better results for density.

Fire proof design

Related to the type of building, proximity to other buildings, length of escape routes and expected fire-load, it was decided that the renovated straw walls should have a D-class fire resistance.

With the straw as an E-class material, there had to be some kind of board or material that has a better performance on the outside. With the intention of building as much as possible using bio-based and natural materials, several options were found and three of them were used in the on-site test. A hemp-soya board of Greentech: Canapalithos, a woodfibre board of Gutex: Pyrosesist, a medium density fibre board of Agepan: dwd-black.

Based on price, insulation, work-process and more, the Gutex Pyroresist with a C-class fire resistance was selected for this project. At a later stage a more fire-resistant version of blown-in straw was introduced (Classified as B1-s1-d0 according, EN 13501-1) but with the C-class Gutex Pyroresist there was no need for this type of fire-resistant straw.

Thermal resistance

The use of straw gives two important ways to reach the required inner climate conditions. First of all, the straw will insulate against heat loss (lambda = 0,045). Additionally, the straw has a density of about 110 kg/m^3. With this weight, the straw will store a lot of summer heat during day-time and will release this during night-time.

For the Tilburg project the thermal performance of the Dutch straw was compared with the blown-in straw from ISO-stroh and Sonnenklee. As expected, all the blown-in straw types had a lambda value in the range of 0,045-0,047. This investigation, carried out by Kiwa, showed a possible relation between particle-size and lambda value: smaller straw parts gave a slightly better performance, which is possibly related to the infrared part of the heat transfer.

On the other hand, smaller straw was more difficult to handle by the equipment we used. If you put too much material into the machine at the same time, it will block and you have to remove all the straw from the machine and start again. As can be seen from our tests, ISO-stroh was the best combination of particle size and thermal performance without blocking the equipment.

13 TECHNICAL ARTICLE: Life Cycle Assessment (Belgium)

What is a Life Cycle Assessment?

Life Cycle Assessment, or LCA, is an environmental accounting and management approach that considers all the aspects of resource use and environmental releases associated with an industrial system from cradle to grave. Specifically, it is a holistic view of environmental interactions that covers a range of activities, from the extraction of raw materials from the Earth and the production and distribution of energy, through the use, and reuse, and final disposal of a product. LCA is a relative tool intended for comparison and not absolute evaluation, thereby helping decision makers compare all major environmental impacts when choosing between alternative courses of action[1].

1 M.A. Curran, in Encyclopedia of Ecology, 2008

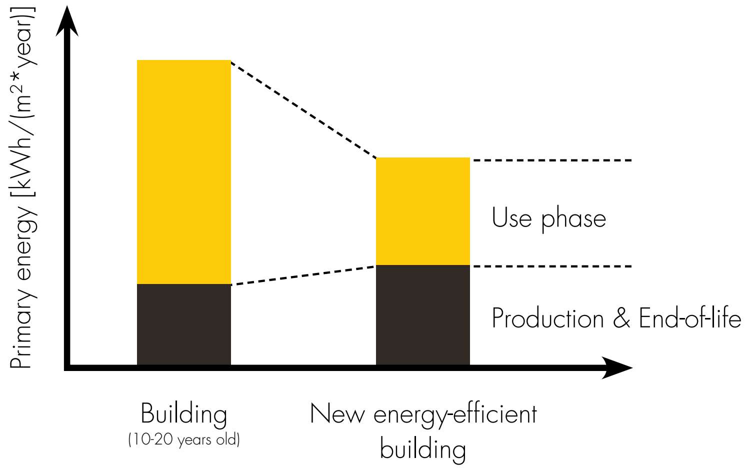
Why is LCA important for the construction sector?

In the last 20 years energy efficiency has become an increasingly important aspect of the planning and evaluation of buildings, as well as a subject of legislation within the EU. As a result, the operational energy consumption of new and refurbished buildings has decreased considerably during this time.

Figure 1 shows the ratio between the operational energy (for regulated uses such as heating, ventilation, cooling and lighting according to the EPBD) during the use phase, and the embodied energy due to the fabrication of the building products as well as their end of life (EoL). The use phase for older buildings dominates all other life cycle stages. Today, new buildings may consume less than 15 kWh final energy for heating per m^2 per year if they comply with the Passivhaus standard. The new types of 'energy surplus' or 'positive energy' building may even be net producers of energy. Therefore, the ratio between operational impacts (the use phase) and the embodied impacts (e.g. for production and EoL) is now more or less balanced.

These changes emphasize that as well as optimizing the use phase of a building it is also important to consider the embodied impacts of the materials used in its construction. As a result, the Energy-Efficient Buildings Initiative now needs to consider a life cycle perspective 'from cradle to grave', with energy consumption being only one environmental aspect within a multicriteria framework that includes, for example, waste generation and climate change. Straw as an insulation material could meet this challenge by offering high levels of insulation associated with a low environmental impact material.

Figure 1



Case study : Notre-Dame de Bon Secours school

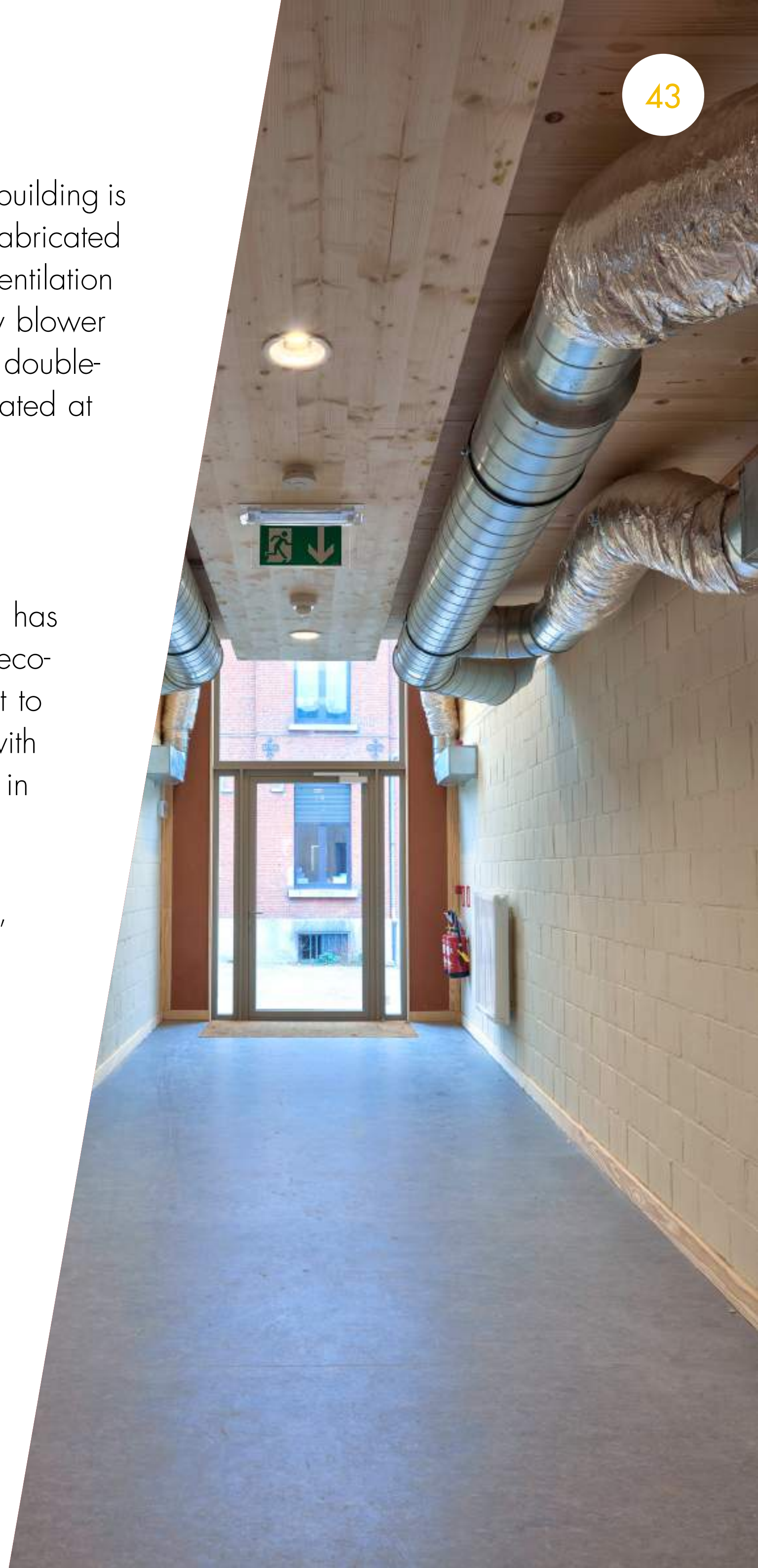
The Middle School in Binche has been the first school using straw for insulation in Wallonia (Belgium). The building is in use since 2017 with a usable area of 532 sqm for 8 classrooms. Straw is used for walls based on prefabricated panels with clay plaster provided by Paille-Tech company. Roof and ground slab use cork as insulation. Ventilation is provided by a dual flow unit with a heat exchange efficiency of 80%. Air tightness was estimated by blower door test at 0.51 ACH, lower than Passive house requirement (0.6 ACH). The outer windows are made of double-glazed glass. The heating consumption has been calculated by energy building simulation and is estimated at 37 kWh/m^2.yr.

LCA of the School

In Belgium a tool for the environmental assessment of construction products at building level, TOTEM, has been developed by the regional authorities. For the time being this tool uses generic data based on eco-invent data.17 impacts are assessed and additionally, monetisation factors are applied to each impact to express single score results. The initial evaluation is based on the existing straw building. An alternative with hemp insulation has been tested. These buildings were also compared to traditional construction solutions in Belgium: Concrete structure with mineral wool insulation and Bricks with PU insulation.

Since the heating consumption method is basic in TOTEM , the heating demand is calculated on COMFIE, a multizone calculation engine for dynamic energy simulations of buildings. 11 Impacts of gas consumption were assessed on OPEN LCA since the detailed data are not available in TOTEM. The gas impact was also monetised. Moreover, alternative using pellets was assessed. Total impacts of products and energy consumption are then summarised by one indicator of impact cost in euros by sqm of gross floor area [€/(m^2.GFA)].

Figure 2 shows the monetised impact of building materials for each alternative. The straw case shows the lowest impact with an environmental cost of 45 €/m^2. The worst case cost is 58 €/m^2 with the brick/PU alternative. Therefore, the straw version saves 27% of environmental cost. It should be noted that the difference between these two scenarios is not only due to insulation material. The infrastructure is also adapted to each technique.



TOTEM examines impacts from building lots. It allows designers to identify the most impactful lots and find alternative solutions to significantly reduce impacts. In the case of the Binche school, Figure 3 shows windows are a major impact whatever is the case studied. A low impact building depends on each part of construction. Straw alone does not make a low impact project, but it can be a major contributor in lowering impacts. For instance, straw walls are 1% of the total impact of the school material but walls using bricks/PU are 11% of the total impact.

LCA shows the impact of gas heating consumption is of the same order of magnitude as the impact of materials. Wood pellets burner could reduce by 50% the heating impact but particles emission is higher. This analysis raises an important question: Is it worth moving towards the passive-building standard? The U-Value of the external envelope is already good, and the ventilation unit already has a high efficiency heat exchanger. The most significant area for improvement would be the use of triple glazing but glazing is already a major impact contributor. Therefore, reducing heating impact will increase material impact.

Conclusion

The straw bale building case shows the lowest impact on environment.The whole building materials impact depends on each lot and straw is a relevant option to significantly reduce impacts of the external envelope. Windows are major contributors to the material impact. Designers should choose carefully the type and number of windows since it is a vital organ of the building on which many factors depend: solar and light gains, heat losses, acoustics, comfort of views and LCA.

Building LCA tools can assess the choice of building products and give guidance for designers to reduce the total LCA of buildings. Nevertheless LCA to compare buildings should be used as an indicator as considers material LCA only. Energy and HVAC systems LCA are not really considered yet but it could be a major contributor to impacts.

Figure 2

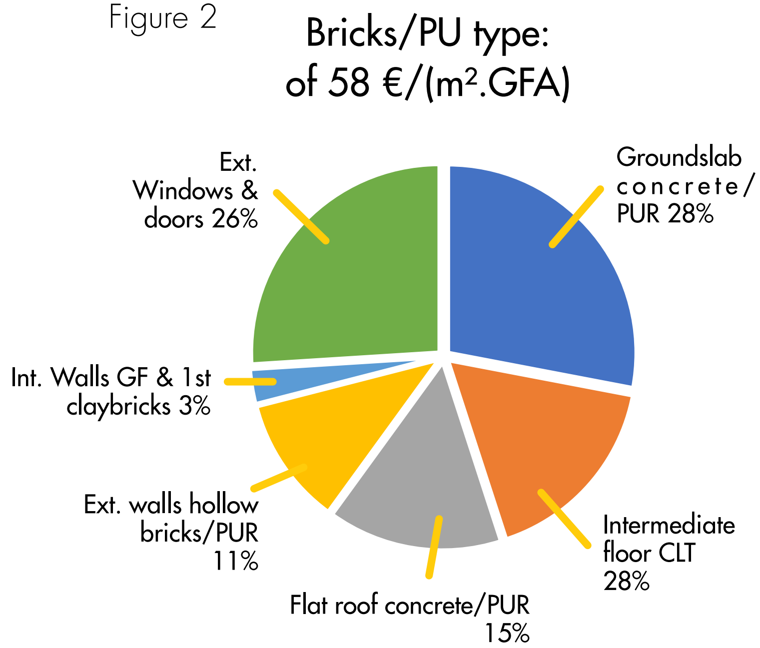
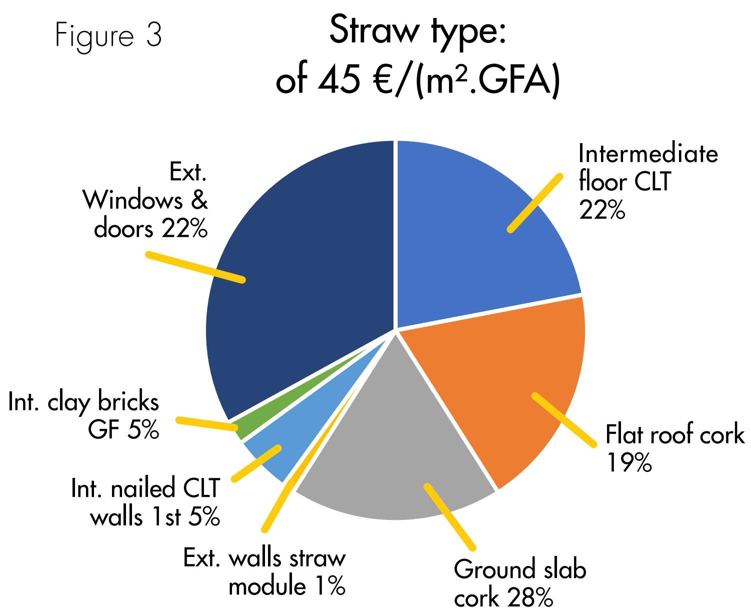


Figure 3



14 USEFUL LINKS / FURTHER READING

Websites

Website Interreg NWE - UP STRAW

Website European Straw Building Association (ESBA)

Website Fachverband Strohballenbau Deutschland (DE)

Website Réseau Français de la Construction Paille (FR)

Website Centre National de la Construction Paille (FR)

Website European Straw Bale Gathering 2019 (UK)

Website Straw Bale (UK)

Website Bau-mit-Stroh (DE)

Further reading

Toolkit and tips straw construction site (FR)

Building with Straw Bales by Barbara Jones (UK)

Dutch and International straw building projects (NL)

EeBGuide Guidance Document Part B: BUILDINGS (BE)

15 PARTNER CONTACT SHEET

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16 COLOPHON

Issued by:
NWE Interreg UP STRAW | February 2020

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