Material Re-use Case Study:

WISER WORKING WITH INDUSTRIAL SPACES TO EXEMPLIFY REUSE

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REDISCOVERY CENTRE

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1. Overview: Genesis of project

1.1. Context of Ballymun

Ballymun was developed as a mass- produced, high-rise, low-density social housing development in the 1960's to alleviate overcrowding in Dublin's inner-city tenements. 3000 apartments were constructed from pre-cast concrete which were produced in a factory based on site in Ballymun. The slab blocks were arranged in long spines radiating from the town centre. 15 storey blocks formed a central ring, with 8 and 4 storey blocks radiating out from the centre.

Figure 1 - Aerial view of Ballymun before the Regeneration

Initially the new flats were very popular. They were spacious and comfortable and there was plenty of open space. This was all in sharp contract to the crowded city tenements that most people were coming from. However, the honeymoon period did not last long. As in other parts of the world where similar housing was built, the flats in Ballymun were not easy to police or easy to provide services for. Recession in the 1970's did not provide the resources to maintain the buildings and in the 1980's, with the advent of widespread drug use, already difficult social issues began to spin out of control. Ballymun had a high level of crime, social problems and it developed a bad reputation.

Figure 2-One of the Ballymun 'Towers'

Local and political campaigning ultimately led to the formation of Ballymun Regeneration Ltd. (BRL) in 1997. BRL was set up by Dublin City Council (DCC) to oversee the economic, social and environmental regeneration of the area. The BRL masterplan was developed, and it set out a programme for building new houses, re-housing residents from the flats to the houses and demolishing the flat blocks. By 2013 BRL had spent almost €1Bn rehousing families into new housing and demolishing the flat blocks, providing new parks and infrastructure and creating new neighbourhood centres.

The future of Ballymun includes the metro to the airport and a new town centre shopping centre which will fill in the gaps in Ballymun's townscape which still requires additional investment. This final work will hopefully transform Ballymun from a no-go area with a bad reputation to a vibrant community that is a desirable place to live, work or visit.

The historic Boiler house, which is the subject of this study, sits in parallel with the development and regeneration of Ballymun. Initially in the 60's the Boiler House was developed to house the district heating system which serviced the new slab blocks. 3000 homes were all supplied with underfloor heating and hot and cold water from the centralised boiler house situated on main street. The Boiler house site included a reservoir for mains cold water supply, oil tanks and an 80m chimney stack.

Figure 3- The old Ballymun Boiler House (2012)

At the time this centralised heating plant was quite an innovative solution, but the system design proved to be very difficult to maintain. There was only one road crossing between east and west Ballymun and if there were any problems with this pipe, 2000 homes had no access to hot and cold water or heating. The system was quite challenging for DCC to maintain particularly when anti-social behaviour effected their staff being able to safely access that various parts of the system.

From a residents' point of view when the system was operational they had free and limitless heat and hot water. The underfloor heating in the flats was very effective, however the individual householder had no control over when the heat came on and what temperature is could be set. This effectively meant that the only control the residents had was to open the window. The complete lack of any insulation in the flats also led to an intrinsically inefficient system.

The overall maintenance and operation issues with the system meant that the overall heating system in Ballymun was not very popular with the operators or with the users and the Boiler House became associated with under-resourced infrastructure that didn't always deliver. When BRL replacement housing became available the residents in Ballymun were housed in new houses that had a normal domestic heating system that they could control themselves. The houses were built to high environmental and thermal standards and they were individually maintained. As more houses were built the effectiveness of the centralised Boiler House was reduced and ultimately it became redundant.

1.2. Demolition programme and decommissioning of Boiler house

In 2010 the Boiler House central heating boilers were decommissioned. The remaining flat blocks were supplied with heat from local containerised heating systems which were also decommissioned as the blocks were demolished and they were no longer needed. The mains water was also supplied via new infrastructure included within the masterplan.
And therefore the reservoir was also defunct.

Immediately following decommissioning the Boiler House was used as a local depot for DCC as it awaited a date for its demolition. The decommissioning process included the district heating boilers, the mains water reservoir, the hot and cold-water pumping station, the oil tanks and the gas supply to the boiler house.

As part of the environmental remit of BRL, the Rediscovery Centre (RDC) was established in 2004 and developed as an environmental social enterprise. To support the development of the circular economy and reduce waste in the area, the RDC set up and developed a number of workshops which upcycled waste. In addition to the workshops the RDC also developed educational programmes and facilitated and delivered translational research on waste reduction, upcycling and the circular economy.

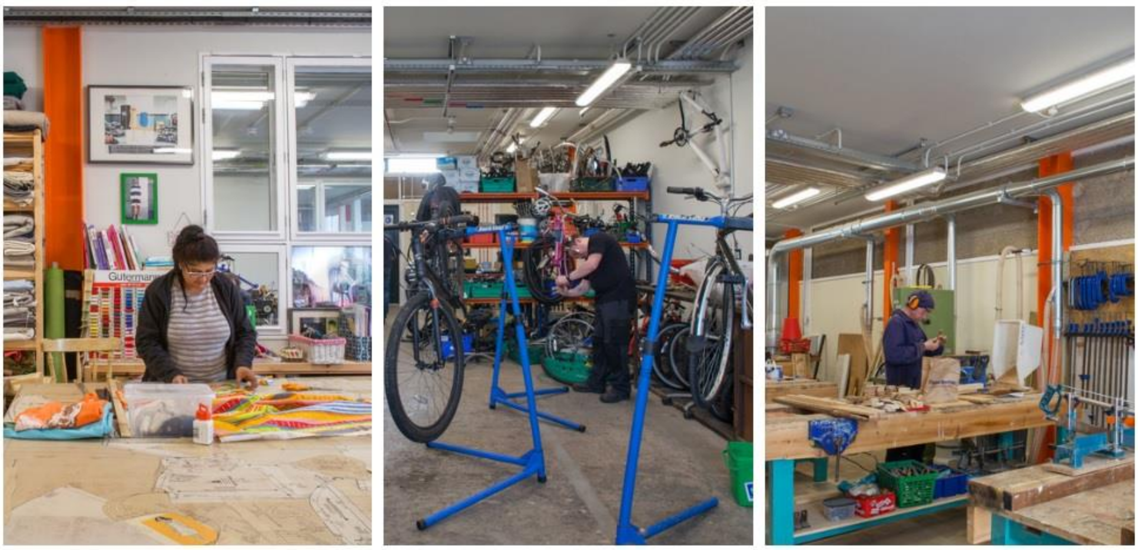


Figure 4 - Social enterprise activity in the Rediscovery Centre

Funding was in place as part of the BRL masterplan to demolish the Boiler House and to present the site for redevelopment. However, the RDC, in partnership with DCC and the Department of the Environment and Local Government (DoELG) were successful in applying for EU LIFE + funding to re-use the boiler house as an educational 3D textbook to showcase the possibilities of waste reduction, re-use and recovery.

As a result of the WISER LIFE project, the Boiler House has now been transformed in Ballymun and is one of the few public buildings that has remained in Ballymun following the regeneration. It has become an important touchstone for residents to remember the history of Ballymun. But it has also been transformed into a place to work, to avail of services and a place to learn, shop and enjoy yourself. This paper uses the refurbishment of the Boiler house as a case study in how re-used and sustainable building materials can be utilised in a refurbishment project and the challenges encountered.

1.3. Opportunity for re-use of Boiler House

The decision to re-use the Boiler House had many positive benefits and implications but also presented a number of challenges. Initially the project began as an effort to find a suitable headquarters for the RDC that could facilitate re-use demonstration and environmental education. The RDC had offices in the Civic Offices, it had workshops in three different locations around Ballymun and it had store rooms in other locations. There were human resource and logistical consequences of having a small organisation dislocated around the town of Ballymun and clearly benefits from co-locating all services and operations.

When the Boiler House was first suggested as a possible location the obvious synergy between an organisation the re-uses materials finding a home in a building that has been re-used were apparent. There was also an interesting link in the Boiler House as a heavy energy consumer being reinvented as a centre of excellence in sustainable development and the circular economy.

As part of the BRL masterplan the site was due to be developed as a main street mixed use (residential and retail) site, beside the newly built Travel Lodge Hotel. In the Celtic Tiger years there was plenty of scope for this kind of development, however as the economic crisis unfolded development of the sites and return on investment became more difficult. Keeping the Boiler House in-situ at least in the short term became a realistic and generally positively received option. It provided a valid use for the building in an area that wasn't going to be developed otherwise.

The enviable town centre location, a short distance from the Dublin City Centre and beside the international airport provided the possibility that the building would become a public space and potential eco-destination for Ballymun; a place for people to come to shop, to learn, to have a coffee and to see the circular economy in action.

Finally, if the Boiler House was going to be used, there was the opportunity to use the refurbishment of the building itself as the educational engine to do the teaching. This was the point where the 3D textbook idea began to emerge. The RDC was not going to make a headquarter building, it was going to make a place that where you could learn how to use waste more creatively and ultimately help people change their behaviour and habits in relation to the use of natural resources. The building was positioned as the working stage-set upon which action for the circular economy would take place.

This presented the project team with a challenge. How do you change a structure that was designed to lose heat into a place that demonstrates environmental best practice which generates and conserves renewable energy? How do you make this change using wasted or sustainable resources? How do you take a disused industrial building that was not a welcome space for visitors to one that no-one had any access to and make it into a public building used for education, manufacturing, and retail? How do you do all this in a place that has one of the worst reputations in Dublin? And how do you fund this project in the middle of the biggest economic crisis ever in the state?

These challenges were of course trivialised when compared to the much larger challenge facing the planet. How do we use the available resources around us in a more sustainable way so that we sustain rather than destroy the very resources we depend on to live? These challenges are global and for many people seem insurmountable. However, as shown by this project, it is possible to solve problems and it is in the engagement with the challenge that we find the really creative solutions.

2. Design:

2.1. Design team.

The sketch design for the building was completed by the RDC and BRL. While the design team had experience in environmental and low energy design, it was recognised that the unique nature of the project, including the use of waste materials, meant that the design team were attempting to do things that they hadn't done before.

Therefore, during the design process aspects of design were included which required other work to test if they were viable and achievable, but they were necessary if we were to achieve the objectives of the project. These aspects depended on others at a later stage in the project to design these elements. Additional funding may also be required.

Additional advice was provided on materials, costs, structure and energy analysis. A list of the design team for the project is provided below.

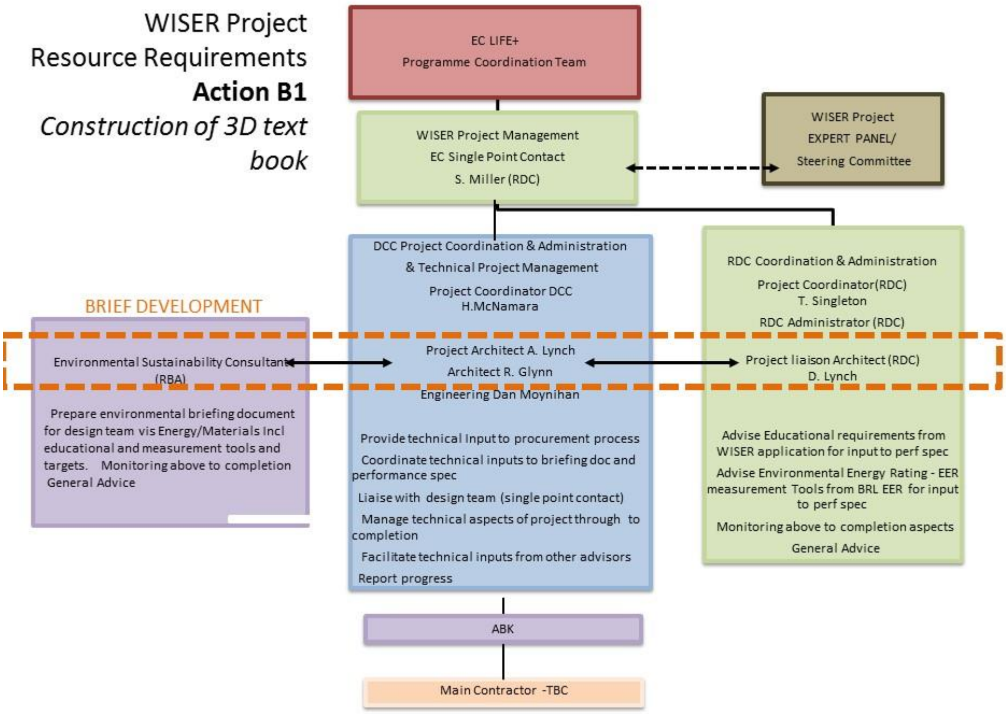


Figure 5 - Project Design Team

2.2. Principles of design.

The overall scope of the project was indeed challenging. A disused industrial building which was designed to lose heat was to be re-used as a low energy public building to promote re-use. All the materials used were to be re-used or sustainable and preferably be sourced locally.

As the objective of the 3D textbook was to be an educational resource it became clear from an early stage that it was important to try to demonstrate excellence and best practice wherever possible. Even if a particular ambition or aspect of the building was impossible to achieve, it was important to discover why not, in order to understand the barriers to environmental excellence & material re-use in order to communicate them in an attempt to remove barriers and support circularity.

The project set ambitious targets for re-use, energy efficiency and waste reduction. They included

- 80% of the energy used in the building would be generated on site
- All foul water would be treated on site.
- Waste would be prevented and re-used

The basic principles of material use were applied for the project on a hierarchical basis as follows

- Re-use of salvaged elements from the boiler house
- Re-use of other materials.
- Use of sustainable or renewable materials
- Use of local materials
- Use of other materials

This hierarchy became established in the project as the means of selecting which materials to use. Factors of cost, certification, procurement and availability were also considered.

2.3. Elements of design.

The first aspect of design was based on materials available on site. These included:

- The structural frame of the building including the slabs and floors.

This was not designed to current standards and additional bracing was allowed for to stiffen the frame structurally.

- The red steel cladding used at low level on the building.

There was a significant quantity of this, but some was in poor condition. This was included in cladding to sliding doors on the front face of the building.

- The aluminium fins at high level ventilators.

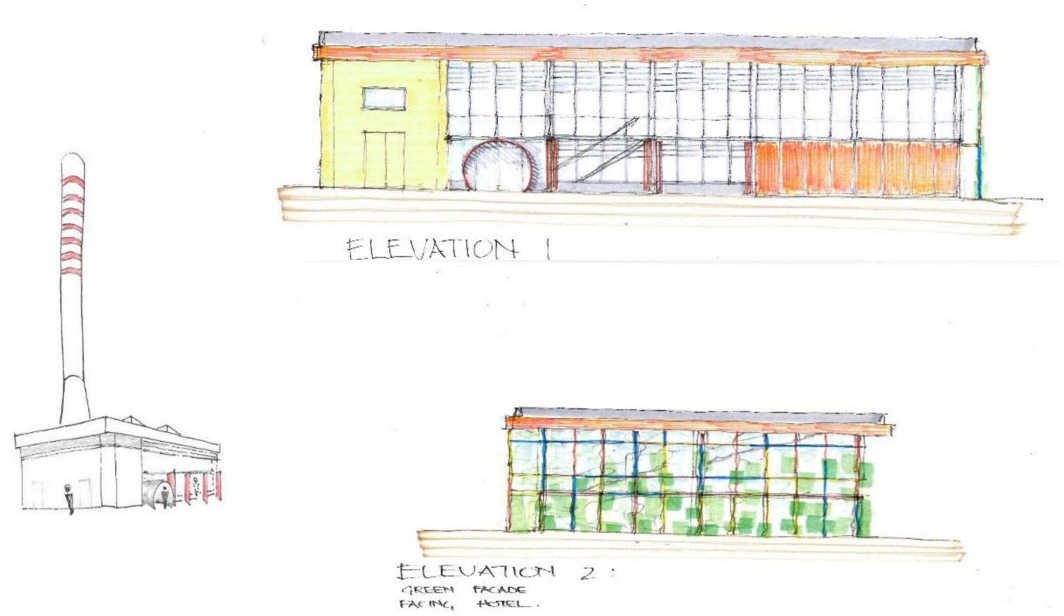
These were easily removable and were included as a cladding material.

- The steel gantry and pipework within the building.

There was a large amount of structural steel within the building. This was included as a steel screen to the south elevation.

- The existing roof.

While the existing roof was leaking badly we included for the repair and re-use of the existing roof.



Elements of the building which were not incorporated were:

- Oil tanks as these could contaminate the site.
- The water reservoir as this was thought not tall enough to be used
- 4 x 9.5 mW boilers. It was planned to sell these to raise additional funds.
- Plastic laminate cladding. This was old brittle and in poor condition.

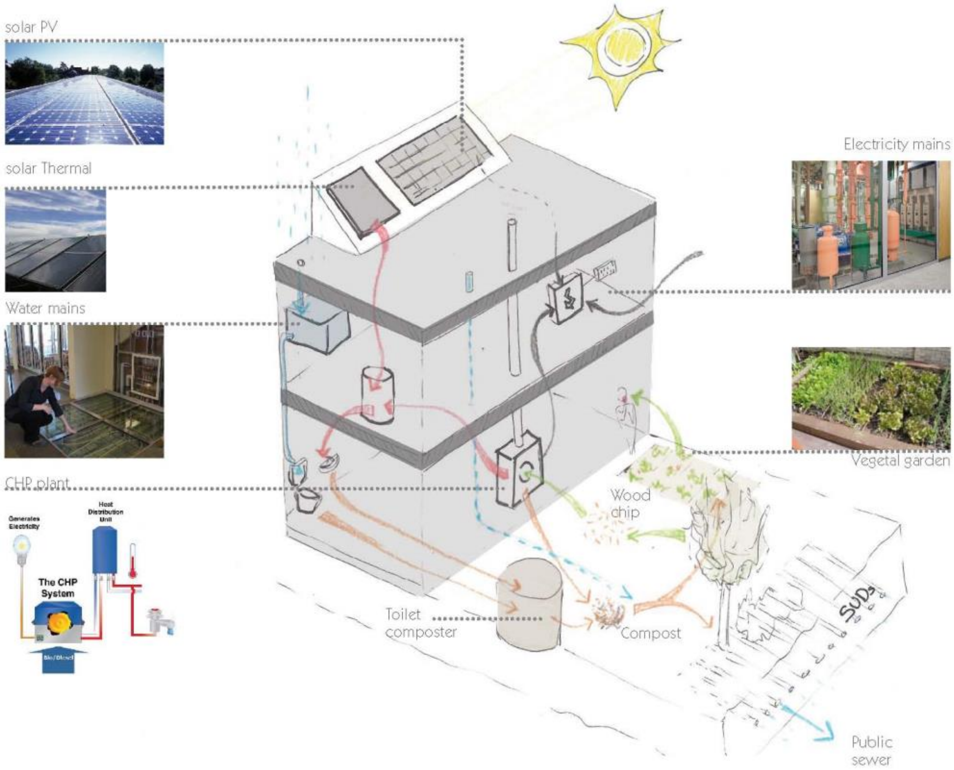
There were also materials identified locally that were included in the design. These included:

- Concrete from existing flat blocks to be demolished and from demolitions on site.
- Earth: To be used in earth walls.

The services to be included in the building were based on demonstrating as many closed loops as possible so that visitors to the building could see as many different systems in action as possible. These systems included:

- Rainwater harvesting: This would be used to flush toilets and irrigate the landscape.
- Reed bed: This would be used to treat the foul water from the toilets.
- Composting of solid waste: This would be used to treat the solid waste from the toilets and the compost would be used on the garden.
- Urine collection: This would be used as a fertiliser for growing green compost.
- Solar water heating: This would be used to supply hot water to the building.
- Solar PV panel: This would generate electricity for the building.
- Combined heat and power plant: This would burn material grown in the garden to produce heat and electricity for the building.

The overall goal was to design a low energy building that would achieve an A3 BER rating and generate 80% of the buildings heat and power on site.



3. Planning and Funding

The Part 8 planning process was completed by BRL architects and planners. In general, there was a lot of support for the project locally and among the local representatives. In terms of the overall BRL masterplan for the main street it was still possible for the Boiler House to be used and for the site fronting Main Street to be developed.

Once planning permission was approved a Fire consultant was procured to complete the Fire Cert and Disability Access Cert for the building, based on the Part 8 design. This process was straight forward. Some elements of the construction were rated to be fire resisting and this rating was carried over into the overall detailed design of the Building.

The next stage was to secure funding for the project. An application to the EU LIFE + programme for 50% of the funding was submitted. The remaining funding was supplied by the Department of Environment, Housing and Local Government who contributed the funding allocated for the demolition of the Boiler house, and DCC who added the remaining funding. The funding phase of the project took almost 3 years to complete as revised applications were required and commitment of funding took some time to put in place. The commitments for funding and the responsibilities for delivering the various aspects of the projects were set out as part of the Life+ application and a project partnership agreement.

Once the funding was approved and put in place the design team could be procured. To set out the requirements for the design team additional information was prepared to form the brief for the design team. Bevan Architects prepared a materials specification which included information on the intent of what materials were to be used and what materials were not to be used on the Project. It was important to provide this additional information so that the scope and type of materials to be used on the project were clear and part of the essential deliverables of the project regardless of what design team was procured.

Additional information was also provided on the space requirements for the various functions in the building and the functionality of the building as a whole to ensure that the 3D textbook would be an integral part of the building project and not just an add on that was included in the fit out. The design team was procured through a public tender. 4 design teams registered an interest in the project but in the end none of them submitted a tender for the project. Under the procurement guidelines the 4 teams were contacted and only one expressed an interest in negotiating an agreement and ultimately this team was appointed to the project.

This process was quite difficult for the following reasons:

- The public procurement rules were rigid and very prescriptive.
- The demands of the project were very challenging
- The time and budget for the construction project were very limited
- The government forms of contract transferred considerable reasonability onto the design team.

Once the design team were in place, work could begin on the detail design of the building and trying to agree what measures in the brief were possible to implement given the budget, and what re-use materials we could use so that the design team could certify them.

3.1. Planning for Re-use - Collection of materials

In parallel with the procurement of the design team the RDC were trying to collect re-used materials that could be used in the construction project. The key aspect of reusing building materials is trying to preserve the value of that material. Many materials are fixed and bonded in such a way as to make it impossible to remove the material without damaging it in some way. In most circumstances this mitigates against re-using the material again. Either the finish is affected or there is some kind of adhesive stuck to the back or the material has been cut to a smaller size. This makes reusing the material very labour intensive and prohibitive in most cases.

There were three main issues that determined the types of materials that could be collected for later use on the project:

- Certification of materials by the design team.

Because of recent changes to the Building Regulations in Ireland CE certs were required for all materials to positively demonstrate compliance with the building regulations. This put the design team in a difficult position in relation to some of our proposed materials in that they were not able to certify them fully and they could not be included in the way that was originally intended.

- Storage of materials:

The only storage space available to the project team was a small local Depot supplied by DCC in. The space was limited and there were restrictions on what could be stored. There was also space to store some materials in the Boiler house itself, but this was outside space only and there was no secure dry space inside that could be used.

- Cost of preparing materials for re-use:

Construction and demolition practices do not generally allow for the re-use of the material. We found that in some cases additional work would be required to make the waste material reusable. The cost of this work made the re-use of the material prohibitive. While the tender design was being developed there were two major opportunities to collect re-used building materials in Ballymun for use on the project.

3.2. Local Opportunities

- The Emerald Project.

This project was a housing project procured by BRL and it incorporated several innovative design features and was designed to be a low energy housing scheme. The builder went bust and the site remained half-finished for several years. This project was being restarted during the WISER LIFE project and part of the housing project had to be demolished. This opened up a huge opportunity to salvage building materials for use on the WISER project.

- Demolition of Sillogue Flats

This was the last of the slab blocks to be demolished in Ballymun. The tender for the demolition did not include the salvaging of any building materials but we negotiated with the contractor to salvage elements of pre-cast concrete and crushed concrete material. These materials also represented a cultural and historical connection between the local community and the WISER project and it was a fantastic opportunity to incorporate parts of the old slab blocks into the new WISER building.

The positive outcomes in terms of material collected follows:

- Supply air windows:

- Sheep's' wool insulation:

In additional opportunities for saving other material were missed. These included:

- Timber Glulam slabs:

As part of the Emerald project a large quantity of solid timber floor slabs were specified and available for re-use. However, during the waiting period when the site was vacant these floor slabs were exposed to the elements and were damaged. Even with this exposure damage, the material could have still been used for partitions or screens however, in this project it was not possible as we did not have enough space to store them and the funding for transporting and storage of the material off-site was not available.

- Timber frames:

The Emerald project was constructed from timber frame and there was also a large amount of timber that could have been salvaged. Again, this was not possible because of storage space, certification of the timber and the cost of preparing the timber for re-use.

- Concrete material from demolition project.

At the on-set of the project we negotiated with the demolition contractor appointed to Sillogue block demolition to salvage some of the precast concrete elements from the flat block. These included balcony railings and wall and floor panels. Despite the contractor's best efforts this was not possible because of the height of the blocks, the method of demolition and the construction of the blocks. Extra cranes would have been required which would have added cost and delay to the demolition contract. No funding was available for this.

As a final option, we negotiated with the contractor to get a delivery of crushed concrete for re-use from the demolition. The re-use involved getting approval and buy-in from the design team to use the material. Crushed concrete was considered as a viable material for re-use in gabions, or as aggregate in cast concrete walls or as a last resort as crushed fill needed for landscaped areas. Following assessment the design team approved the re-use for crushed fill.

Estimating the quantity of the material which could be re-used was also important because we didn't want to stockpile material, to cause an obstruction or to delay to the contractor on the WISER LIFE project. It also involved getting permission from DCC to store the material on site during construction for this short period. It was agreed that a quantity of the material would be delivered from the demolition site to the WISER LIFE project site on route to the Landfill. This detour would result in a diversion equal to a distance of 300m.

As such, the timing of the delivery was agreed as late as the Sillogue demolition would accommodate so that the WISER LIFE project programme and construction would not be adversely affected by the delivery. The execution of the delivery task however was not as straight-forward as anticipated. On the day when the material was due to be removed the employee who had agreed the donation was not on site. All of the material was sent to a landfill site instead.

This incident was a useful learning experience highlighting the complexities involved in direct construction material donation and re-use for a relatively common material.

3.3. Tender

Once the Design team was procured and appointed by DCC, we had the opportunity to fully test the feasibility of the project ideas within the building. While all the ideas discussed above were possible to include. There were key considerations which were necessary. Each proposal was assessed on the following basis:

- Is the proposal practical?
- Is the proposal certifiable by the design team?
- Is the proposal affordable within the funding available for the project?

- Is the proposal possible to include in the building contract?
- Is it the best way to demonstrate the principal of re-use from an educational point of view?

3.4. Initial cost exercise.

The first action the design team under took was a budget cost exercise. This process allocated funding to various elements of the design to get a quick snap shot of the general feasibility of the project. There had been a considerable time delay since the initial cost exercise when the sketch design was completed due to and building costs had inflated.

At this stage the design team were also able to make their first detailed inspections of the building. They were able to decide on what elements of the building they were prepared to re-use, and they conducted a number of initial tests and inspections to verify the condition of the building.

3.5. Initial design review

The design team were quickly able to verify some of the main aspects of the design:

Structural Frame



The structural frame was able to be re-used. It was in good condition and there were no areas of rust and deterioration of the frame. However, the steel frame did not comply with current structural standards and additional structural members would be required to stiffen the overall frame.

External walls: A simplified solution for the external walls was proposed. In the initial sketch designs a number of different types of wall were proposed but this was considered too complex and too expensive. It was agreed to proceed with one type of external wall on the east, west and south facades that was to be made with a timber frame supported by the existing structure, insulated and stiffened with hempcrete. There was a cavity wall on the north façade of the building and it was agreed to pump the cavity with insulation and externally insulate the wall with wood fibre insulation.

The specification for these walls was included in the material specification.

Roof: The roof was in poor condition, but it was agreed to retain and repair the existing roof finish as a vapor barrier and fit a new insulated roof finish above the old one. The parapet wall was not in good condition and it was agreed to remove it and replace it with a low parapet to retain the overall proportion of the building. This parapet was not high enough for guarding purposes and a fall arrest system was required to facilitate maintenance. Additional structural support was required for this.

3.6. Retention of the reservoir

During this period further site investigation were carried out. Following the decommission of the water reservoir on site it was discovered that the height of the reservoir was 3.5m high and not 2.4m as previously assumed.

The structure of the reservoir was assessed and found to be in good condition. However, it was not strong enough to support additional load on the roof slab. Some additional work was required to wash out the sludge in the reservoir and disconnect the overflow from the surface water system. This work was completed by DCC.

An assessment was made of the site design and it was reconfigured to accommodate the retention of the reservoir and all the aspects of the original site design. The scope and position of some of these site aspects had to be changed to accommodate the retention of the reservoir but in general this did not affect the functionality of the building, the outdoor classroom or the demonstration capability of the overall project. On one side of the reservoir additional structural support was required to accommodate the extra weight of a kitchen garden which was relocated to the reservoir roof following the reconfiguration.

Figure 6 - Kitchen Garden relocated to the Reservoir roof.

In terms of the overall project, reusing the reservoir has provided additional useful storage space and also demonstrated another way in which industrial structures can be re-used. The re-use of this structure reinforces the overall aims and objectives of the project. It also demonstrates how flexible structures are and that they can be used in many different ways.

3.7. Access to roof:

As part of the initial sketch design we had hoped to have access to the roof. This access would allow visitors to see the equipment on the roof up close. We had proposed to locate solar panels, weather stations, green roofs, bee hives and other environmental projects on the roof. Access to the roof would also allow a view of the site, Coultry Park, Ballymun main street and Ballymun and Dublin generally. It was felt that it would be an exciting aspect of the building for a visitor and it would allow RDC to run various projects on the roof and increase the space that was available for them.

However, there were two aspects of this idea that were not feasible for a cost point of view. The loading on the roof would require much more structural intervention and this cost was prohibitive. Also, if access was provided to the roof we needed to provide access for people with disabilities. This required an additional lift, additional structure, and additional space. It also provided difficulties with escape from the roof in the event of an emergency.

Various ideas were explored which included providing access to the roof from the chimney, restricting the area of roof that was publicly accessible and extending the existing lift to the roof, but each of these ideas was not possible in terms of the overall costs plan.

It was agreed to only provide access to the roof for maintenance. The green roofs were relocated to the roof of the reservoir as a demonstration, and we provided a large mirror which formed a kind of periscope in the rooflight to provide a view of the equipment on the roof.

Figure 7 - Site works and reservoir retention

3.8. Services

The design team also reviewed the proposals for the various services that were to be provided in the building. The general principle was to provide several different systems to demonstrate different sustainable technologies. These systems were to form a closed loop as much as possible so that the waste from one process could be used as the fuel for another.

This was not possible in all cases. For example, we wanted to use a bio-mass combined heat and power (CHP) unit to provide heat and electricity for the building. Bio-mass CHP units are available for domestic and commercial projects but none at the scale that was required for the Boiler house. The agreed solution was to provide a gas fired CHP unit that would provide the base load for heating and power for the building. In addition to this we would provide a solid fuel stove. Willow grown on the site would be coppiced, dried and burned in the stove and the heat output of the stove would be recorded. This process would demonstrate different ways of heat the building and the proportion of heat provided by each system. We would also be able to demonstrate how much willow coppice we would require to heat the whole building using only the stove.

3.9. Existing Boilers

At the time of decommissioning the district heating boilers had been used for about 10 years and they were still in good condition. Each of the 4 boilers had cost €100,000 each and when they were decommissioned DCC were made an offer to sell them for €25,000 each, we had believe there was value in the boilers however 4 years later the landscape had changed. We approached several parties who may have been interested in buying the boilers, but we were unable to find a buyer. This was unfortunate as the income from the sale of the boilers was going to be used for other aspects of the building that were difficult to fund.

The only option available to us was to sell the boilers for scrap. The scrap value of the boilers just covered the cost of removing the boilers from the building and transporting them to the recycling company.

This was an example of the value of an asset diminishing over time and being reduced to it's lowest possible level. In fact, the boilers became a liability rather than an asset.

One of the boilers was retained on site in commemoration of the old Ballymun and what the building had been historically used for. Various parts of the boilers were also retained to be used as part of the fit out for the building.

3.10. Material re-use

As part of the demolition works a list of materials to be salvaged for re-use in the building was drawn up and included in the tender. This list included parts of boilers, steel pipe, furniture, tools and equipment. All the materials were photographed and labelled, and the steel pipes were cut into 2.4m lengths for re-use. The aluminium fins from the top of the building were also identified as materials for re-use.

A number of materials from the list were deemed unsuitable for re-use they included the red steel cladding at low level on the building. This cladding was badly rusted in places and would have been further damaged when trying to remove it.

3.11. Procurement

Because the project was being funding by government funds, public procurement rules were applied. For the most part this was not problematic. Tenders had to be publicly advertised, agreed forms of contract had to be used, no brand names or specific suppliers could be referenced and compliance with other areas of Irish and European law had to be demonstrated, such as tax compliance and certification of materials etc. There are good reasons for having public procurement. It provides a fair and level basis on which to compete for government projects. The procurement rules are also in place to prevent abuses such as design teams benefitting from specifying particular materials.

However, there were two areas in relation to this project where public procurement impacted upon re-use innovation and made getting what we wanted more difficult.

1., Restricting the supply of unwanted material: Materials specified ad the work requirements within the contracts are described in performance terms and no specific suppliers or brand names can be used. In some instances, we had identified materials that we wanted to use, and described it in performance terms. However, we had also identified material of similar performance that we didn't want to use and in fact wanted to prevent these materials from being used on the project.

An example of this was the hemp for the external walls. There are a limited number of hemp suppliers. Some of these supply suitable material for the construction of external walls and others don't. Because hemp is not used very much, a detailed knowledge of hemp is not common in the building industry and it is difficult for non-experts to be able to identify good material from material that is going to cause long term problems in the building. It is also easy for suppliers to claim that their product complies with the performance specifications for the same reason.

From the contractor's point of view, he is also interested in providing good quality material and is only interested in providing the client and design team with what they want. From a competitive point of view however and all things appearing equal, cost will be the deciding factor in many cases.

2. Foul drainage treatment system: The design team spent a lot of time and effort with a specialist sub-contractor designing the foul waste water treatment facility. This system was also connected to the rainwater harvesting system and the urine treatment system and was both innovative and experimental in terms of a public building. There were many rainwater harvesting systems available on the market and this element of the design was identified as a generic system with connections to the other foul water systems. However, there were not many reed bed systems available and there were no urine treatment systems available. These two elements formed part of a bespoke piece of design.

Designing, installing and maintaining this system was critical to the proper functioning of the building's drainage system. We tried to find other suppliers who could provide this service but were unable to identify a viable alternative to the system designed.

This provided us with a procurement issue. We knew what we wanted and had a supplier who was able to provide us with the system that we wanted. But because we could only find one supplier we were unable to procure that supplier and we were also unable to name that supplier in the tender.

The danger was that the contractor would try to procure this service from someone else and end up pricing something that we didn't want. In the end the preferred contractor was subcontractor was the one chosen.

Both these procurement issues were unique and complicated the process further.

3.12. Final pre-tender estimate

In the final tender package, the items of practicality, procurement and feasibility were resolved, and decisions were made on the basis of cost. If an element of the building was not achievable for cost reasons we tried to achieve a similar educational objective in some other way.

There were a number of items in the tender design that were slightly over budget, but they were included on the basis that if the tenders came back under budget the item could be included and if further post tender savings were required they could be omitted.

3.13. Tender and appointment of contractor

The tenders were advertised on E-tenders as a restricted tender and expressions of interest were invited. Following a quality review, a shortlist of 5 contractors were invited to submit tenders for the project.

One of the main issues post tender was that the estimated budget was much lower than the actual tender returns. The inflated tender returns reflected the difficulty in pricing the re-use and recycled elements of the building. It also reflected the unusual nature of the project and the fact that the materials were not conventional.

Purcell Construction (PC) was appointed as contractors. Additional funding was required and provided by DCC and DoELG. An additional €100,000 of savings were made by omitting work.

4. Construction

Following the appointment of PC as contractor, a construction programme was put in place which determined timelines for resolving any other issues with material supply.

4.1. Demolition material

All salvaged material was collected and stored by the contractor for use in the fit-out of the building. They including:

- Water and steel pipes
- Doors, controls and burners for the boilers.
- Misc. fitting and fixtures from the building
- Aluminium louvres
- Brick
- Earth and fill

4.2. Re-use of steel pipes

Some of the large diameter steel pipes were re-used as the surrounds on the planters for the kitchen garden on top of the reservoir.

Other smaller diameter pipes were re-used by an artist in creating an impressive hanging sculpture for the entrance hall.

Other parts and fitting are proposed to be used in the reception desk.

4.3. On site re-use

During the works several opportunities for re-use were taken using material found on site:

- Bicycle racks were identified by the contractor from another project and were re-used.
- Precast concrete beams and lintels used to cover a manhole housing a district heating junction were re-used in the landscaping area forming part of an attenuation swale.
- Sluice sinks were collected from a disused lab and re-used in the workshops. These sinks needed new legs to be fitted so that they were installed at the right level.
- Bricks were salvaged from other sites.
- Sheeps wool insulation
- Supply air windows
- Teak wood for benches and tables
- Beer crates for child seats
- Wooden crates for café tables

4.4. On site re-use that did not happen

Following on from the tender there were some items that could be re-used but did not happen. These included:

- Roof: When the roof was inspected on site it was decided that it was not able to be used. There was a board used as a deck below the waterproof finish and this was completely saturated. This roof was stripped and replaced with a new membrane in order not to trap moisture inside the building.

- Roof insulation: A foam glass insulation was specified for the roof. This is a non-petrochemical based insulant. However, post tender this was omitted for conventional insulation to save money to bring the project back within budget. We tried to find alternative re-used insulation, but this was not available in the right quantity for the project and new insulation was used on site.

4.5. Waste management

During the construction process the contractor implemented a waste management plan that separated different materials for recycling, re-use and recovery. Minimal material was separated for disposal.

4.6. Building performance

The overall BER rating for the building was higher than targeted. The design specification detailed an A3 BER rating but in practice a higher A2 rating was achieved for the following reasons:

- Better air tightness was achieved on site than the pre-construction estimate.
- Achieved extra credit for sustainable heating systems
- High u-values were achieved for the materials that were being used.

5. Post occupancy evaluation

Figure 8 - Building progression

5.1. Material Re-use

Set out below is a list of the various elements of re-use that were used in the building.

5.2. Re use of existing structures:

Boiler House: This may seem obvious, but the retention of the structural frame and the re-use of the existing building was the single largest measure of material re-use in the project. It is common on many projects that existing structures are initially removed from site. Unlike many of the components in a building, the structure of the building is designed to be stable and robust in the long term. Consequently, the life span of a building structure can easily be 150 years.

Given that the structure has a long-life span, and a high cost of production, it makes sense to build structures flexible enough to accommodate several different uses over their life span. In most cases this is the best way to maintain the value of the structural frame. In a demolition situation the value of the frame is reduced to crushed stone fill, or it is used for landfill.

This fact should be considered at planning stage of buildings in general. The structural frame should be retained as a piece of 150-year infrastructure that could be re-used for many purposes during its life time. The cladding, services and fit out of the building have much shorter life spans and can be changed several times during the life of the building frame.

Reservoir: The inherent flexibility of structures has been demonstrated by the re-use of the reservoir. It was originally thought that the internal head height was too low for the structure to be re-used. Once it had been established that the space inside the reservoir was high enough, it was apparent that it would be possible to use it for lots of different functions.

One of the restrictions with the WISER LIFE project was that there was no funding to develop the space in the reservoir for anything other than a store room. The money saved by not demolishing was needed to reorganise the site and accommodate the other site functions that were required as part of the WISER project. The space allows future development and once insulated and damp-proofed it could be used for many different uses.

Shipping containers: There were a number of shipping containers on site one of which has been re-used to house a composting machine. There are many examples of reusing shipping containers ranging from storage spaces to housing and they are very useful as a modular mass produced structural unit. The containers on site were not in very good condition. The one re-used had to be re-roofed and the door had to be repaired.

5.3. Sub-Structures

The existing foundations were used wherever possible. Some additional foundations and slabs were required at the perimeter of the building. These foundations were insulated and provided perimeter insulation for the entire ground floor slab. The insulation used was convention XPS as there was no sustainable insulation material that was suitable for this application. We considered using foamed glass insulation, but the cost was prohibitive.

5.4. Structural Frame

The existing steel frame did not fully comply with current standards and additional bracing needed to be introduced and stiffening of joints completed in order to re-use the frame.

This proposal however was practical, desirable and achievable. 3D assessment of the structure allowed minimal interventions to the frame to allow it to be certified by the structural engineer. These interventions were affordable and easily incorporated into the contract.

However, the re-used structural steel from water and gas pipes and steel gantries from the Boiler House were not included. The condition of these pipes could not be certified in structural applications. Therefore, it was decided to include the salvaging of some of this material in the tender and the steel could be used in decorative applications for the internal fit out. Various other items from the boiler house were also included in this salvage element of the project. All salvaged items were to collected and stored on site in an existing shipping container and this material used in the fit out of the building to restore the industrial aesthetic of the original boiler house.

The pipes were re-used in a number of ways including in a sculpture in the entrance space, in the upstands for the kitchen garden on the roof of the reservoir. The remaining pipes are being used to make furniture in the RDC workshop.

5.5. Floors and Floor finishes

The existing ground floor was retained and re-used, however most of the first-floor level is a new floor. A floor made of simple timber joists was considered but this required additional steel for some of the spans. To reduce the embodied energy of the floor design 'easi-joists' were used. These joists are not just more sustainable, but they use less material than simple timber joists, there are easier to manage on site and they provided space for services to pass through.

The floor finishes used were very simple. The existing concrete slab was ground down to remove unevenness and surface damage and was polished. This has provided a very robust finish to the workshops and the ground floor entrance. On the first floor OSB boards were used. These are all screw fixed to allow for re-use.

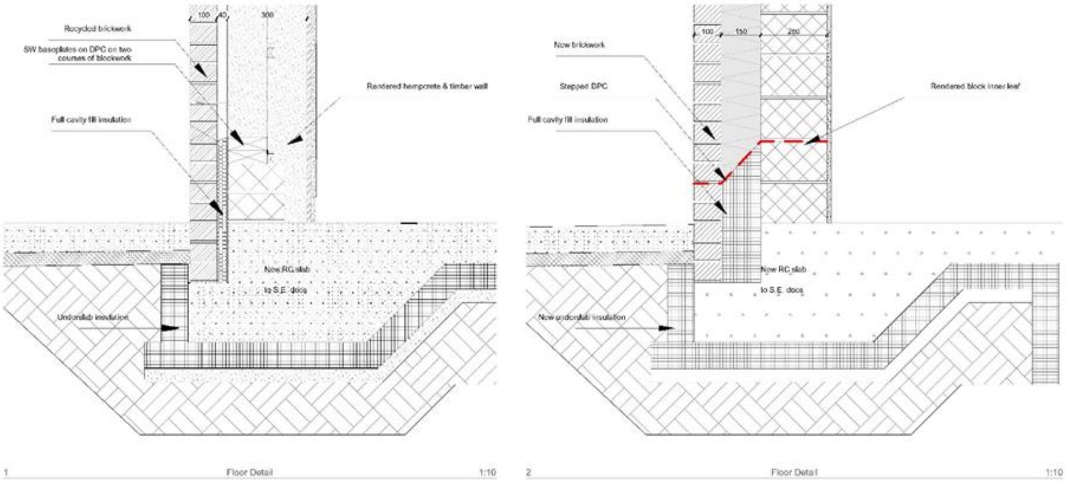


Figure 9 Comparison WISER LIFE Floor V's Conventional Finish

5.6. Walls and External Wall finishes

The following wall finishes were not used:

The existing red metal wall cladding on the Boiler House was not practical to use. It had been riveted onto the cladding rails and was difficult to remove without damaging the sheet. Most of the sheets were badly rusted and were not robust enough to be re-used.

The precast concrete elements from the demolitions of Sillogue flat blocks were also not possible to use. Most of these panels were cast into the structure of the flats and the method of demolition made it impossible to salvage any undamaged parts. Additional cranes would have been required to remove sections of the flats. This was not possible in the original design of the flat blocks, or in the demolition contract. It is a good example of how the value of material is reduced to its lowest value in the conventional construction and demolition process.

Wall finishes that were used:

It was decided to make the walls out of timber frame. This is a renewable natural material, but we were not able to re-use timber for certification reasons. Using re-used timber would have needed additional labour to prepare the timber, remove nails and cut away damaged sections. The timber would have needed to be stress tested again. This additional cost is preventing structural timber being re-used widely. Salvaged timber from demolition is usually burned.

To infill, insulate and stiffen the timber frame it was decided to use hemp and lime. This provides a natural renewable material that has structural and insulation qualities and is also breathable and supports a good internal environment. The contractors completed training on site on how to prepare and use the hemp to create walls. The results of the finish on site were very good and the high-level walls are exposed so that visitors can see the makeup of the walls. The hemp is cast and takes 30 days to fully cure. Shuttering can be struck after a few days. Care should be taken to protect the finish of the help wall once the shuttering is struck as it is susceptible to damage.

In order to clad the external walls, it was decided to use recycled brickwork. Recycled brickwork is one of the few construction materials which have an existing market for re-use. This is because they are used for conservation projects and they are robust and are easy to store for extended periods. To demonstrate the variety of this material a series of different bricks were specified using different brick bonds. This created the variety of different materials intended in the original design.


Figure 10 - Building Finishes

In addition to the brickwork timber cladding was used at a higher level. We were not able to find any re-used timber cladding that could be used on the building. This was due to poor quality of material, re-finishing costs, lack of availability, limited quantity and concerns about longevity of material. Therefore, thermo-treated FSC timber was selected with a stained finish.

The aluminium fins salvaged from the original building were also used as cladding in a certain area of the wall. This produced a very interesting external finish and again demonstrated innovative re-use in building design as shown in Figure 11.


Figure 11 Reused aluminium for external wall cladding

To the north of the building there was an existing cavity wall. It was decided to externally insulate this wall with wood fibre insulation. This insulation is made for a sustainable timber resource and it also has the opportunity of demonstrating an energy conscious retrofit process from a public awareness point of view.

The Emerald project, which had been cancelled, had specified and purchased Sheep's' Wool insulation. Not only is this insulation quite expensive but it is a natural material that is renewable, it does not cause any irritation to users or installers and it performs better that its synthetic alternatives. Sheep's wool had been removed from the Emerald, where it was no longer required, and stored in a DCC depot.

In the first instance our design team had difficulty certifying the insulation as the specific source of the product could not be determined. In order to use the insulation, it was necessary to engage an independent consultant who was able to identify the source of the material, clarify the chemical and physical properties to allow for certification in accordance with the building regulations. The sheep's wool insulation was used as additional insulation for the walls on the north of the building.

5.7. Windows

As part of the Emerald projects they had also specified supply air windows. These windows allowed cold fresh air to pass between two layers of glass which preheated the air and generated a warm fresh air supply for the buildings. The company that supplied the windows had gone out of business and it was not possible to certify the windows for use on the external envelope of the building. Therefore, we salvaged 6 window frames and they were used as internal glazed screens between the workshops as these could not be used in an external wall. If certification was possible and we had more space to store the windows more windows could have been salvaged. The other windows in the building were all new windows.

5.8. Roofs and Roof finishes

During the initial sketch design stage, the roof was difficult to access and a full assessment could not be made. Once the design team were appointed, DCC arranged access to the roof so its condition could be assessed. In the interest of maximising re-use, the design team proposed that the original roof membrane could be repaired and maintained as a vapour layer, and insulation and a new roof membrane could be installed above the old roof.

The design team also established that the budget didn't allow for public access to the roof as the additional loading required would mean that the structure would have to be substantially reinforced. In addition to this a disability access lift and a fire escape from the roof would be required which further complicated the design. Combined these elements made access to the roof unfeasible from a cost perspective.

When the contractor began work on the roof it was discovered that there was a board laid above the steel deck and below the existing roof.

The board was saturated and badly damaged. If the existing roof was to be retained as proposed there would be no way to release tis trapped moisture. It was decided to remove the existing roof.

This was an additional cost to the contract.

Figure 12 - Damaged roof board

The parapet was also maintained around the edge of the roof as the most cost-effective way of maintaining the existing roof finish detail where it meets the edge of the roof. However, the existing parapet is less than 1100mm high and as a result a fall arrest system had to be added to the roof to allow safe access for maintenance. Additional structure was required to facilitate this.

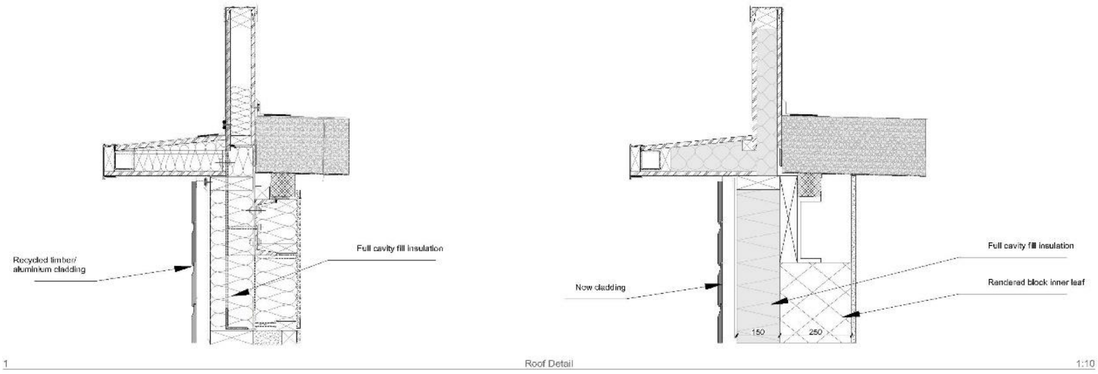


Figure 13 - Comparative Diagram of conventional V's WISERL LIFE roof

5.9. Stairs and Balustrades

None of the stairs in the deconstructed Boiler House were suitable for re-use in a public building. Therefore, new stairs and balustrades were designed. In the sketch design a fire escape stair has been located at the north-east corner of the building. This stair had to be relocated to allow for additional structural members. During this stage of the design it was decided to re-use the reservoir. This allowed for a different solution to the fire escape stair. Instead of providing a stair case to the ground, a bridge was made connecting the first floor of the Boiler House with the roof level of the reservoir.

This intervention had many benefits as it:

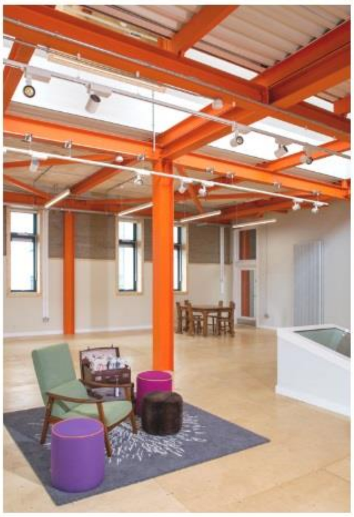
- Provided for the Fire Escape requirements
- Took up less space inside the building.
- Connected the building with the site at first floor level

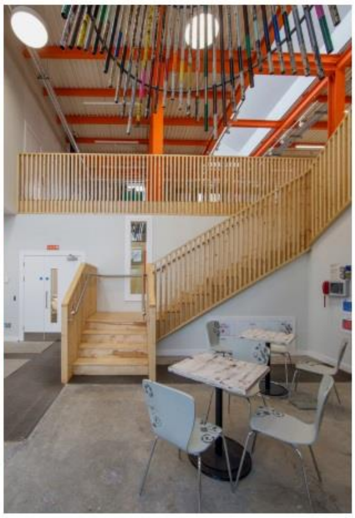
The main stairs in the entrance area was made from timber (Irish Fir) as a more sustainable material. External stairs, including the bridge to the reservoir were made from Galvanised steel.

5.10. Internal Walls and Finishes

As discussed above in section 5.6, the additional costs associated with reusing structural timber also prevented us from using re-used timber for internal partitions. Plasterboard, which is easy to recycle, was used to finish the partitions. In fact some plasterboard manufacturers are recycle gypsum boards by providing a skip on site for waste plasterboard, which is returned to the factory to make more boards. Providing a closed loop system. Manufacturers provide this service for free as the costs for virgin gypsum are increasing. This format could, and should, be used by other building material manufacturers in the future to support the circular economy to reduce waste, decrease costs and improve productivity. As there was no plasterboard in the original Boiler House building this did not happen on the WISER project.

AS mentioned previously, the Hempcrete walls were presented as the internal finish on the upper levels of the inside face of the external walls. At low level, where the wall can be touched, it was finished with a lime plaster. This produced a robust internal finish but revealed the make-up of the wall at a higher level. Again, this met the requirements of the original design intent.





5.11. Ceilings

30 minutes fire protection was required below the first floor. It was considered to treat the floor joists and deck with intumescent paint, but a plasterboard ceiling provided better protection to the structure of the building.

No other ceilings were provided within the building as the design intent was to ensure the services were exposed and visible for educational purposes. Services at ground floor ceiling level were suspended below the ceiling.

5.12. Painting and Decoration

All the internal plasterboard partitions, walls and ceilings were finished with re-used paint as supplied by the RDC's rediscover paint workshop.

Lime plaster required no additional finish.

5.13. Fittings and equipment

There were a number of opportunities for reusing fittings during the project.

First, there were a number of fittings that were re-used from the Boiler House. These included sinks, lockers, equipment and furniture. There were a lot of items that were salvaged from the Boiler house to create a fit out also. An objective of the project was to protect the industrial feel of the building an retain a link to what the original building was used for.

In addition to this there were also local opportunities for reusing fittings. In Ballymun a shopping centre was being demolished which also provided some workshop sinks for re-used. Tables from a café were also reused.

PC identified some fittings left over from other projects which they were working on and these were also reused. These included bike racks and bollards. DCC had some vacant labs on another industrial site that were being used for filming. As part of the film work some of the labs fittings were being removed. The RDC were able to re-use theses and furniture, workshop sinks, and lab benches. Some were used in the main building and some were used in the Rediscover Furniture workshop.

Some of these fittings needed additional fittings and fixings to install them. Collecting the items also needed several visits to the sites to organise approval for removing items.

5.14. External works

Having exhausted opportuntitites to sell the boilers, we examined ways of reusing them as part of the exhibit in the building so that visitors would have some idea of the size of the boilers and what they were used for. The size and weight of the boilers made this very difficult, but the practical difficulties of cutting up the boilers on site made the process cost prohibitive. One consideration was the cut through the Boiler to provide a slice which could be incorporate into the main Entrance however upon investigation we found that this would cost in the order of 10,000-20,000 which was considered excessive.

Finally, it was decided to scrap 3 boilers and install the last one on the rear of the site adjacent to the reservoir.



5.15. Site Services

There were several site services that needed to be decommissioned as part of the final decommissioning of the Boiler House. These included water, gas and electrical supplies. There were also drainage connections on and adjacent to the site that needed alteration, upgrade and diversion to connect the new Boiler House drainage.

Where possible existing drainage lines were re-used and repaired instead of laying new drains.

The main feature of the site services on the WISER project is the foul water treatment system. To demonstrate what is required to re-use the water that we flush down the toilet a reed bed system was installed to treat the foul waste water from the Boiler House.

The solid waste from the toilets is separated and composted in a wormery. The compost from the wormery is fed through the on-site compost machine to sterilise the compost further. The compost is used on site to feed the willow coppice so that is no longer part of the food chain on site.

The waste water is collected in a flush tank above the vertical reed bed. 50 ltrs of waste water is deposited at a time and the bacteria in the water feeds the roots of the reeds as the water filters down through the reed bed. After this the water passes through the horizontal reed bed to be further digested. The water at the end of the process is clean and is fed back into the reed bed or it overflows into the mains drainage.

This system not only demonstrates the practice and principle for treating water, but it also shows how much space is required to install the system.

5.16. Site Fittings

There were some opportunities on site to re-use some material. As discussed above we were not able to re-use precast concrete elements from the last of the Ballymun flats, but we were able to use some pre-cast concrete slabs on site that were used to cover over a large man-hole. These slabs were installed as a seating area around the bio-diversity pond in the car park.

The existing perimeter palisade fence was re-used on the temporary parts of the boundary line at the front of the building. At the exposed permanent boundary, we erected a paladin fence which used less material than the palisade fence and it is easier for plants to be trained to grown around it.

5.17. Services

A comprehensive study of the services was undertaken by the mechanical and electrical engineers. They assessed different potential systems in terms of their educational value, environmental credentials and ability to supply the building with energy required to meet the overall project objectives. The systems used are listed below:

- Rainwater harvesting: A 2000m2 tank was installed on first floor. This allowed the rain water system to be gravity fed. The overflow from the tank feeds an external pond.
- Reed bed foul water treatment system: This was installed in the garden adjacent to the back gate. The different levels of the system are visible from the different levels of the ramp on the way up to the reservoir.
- Composting of solid waste: A carousel system was installed based on worms composting the solid waste. To make sure that there are no contaminants in the final compost used the compost is broken down further by a commercial composting machine on site and then used on the garden.

- Urine collection: A small-scale system was installed based on the urine collected from one urinal. The urine is collected, diluted with water from the rainwater harvesting system and used to feed pants growing in pipes fitted along the west elevation.
- Solar water heating: Solar thermal panels are connected to a large buffer vessel in the ground floor plant room that stores and collects heat.
- Solar PV panel: These are connected to the electrical supply for the building. This power is used first before mains electricity is imported.
- Combined heat and power plant (CHP): A small gas fired CHP was installed. A suitable model that burned biomass and was the right size for the load in the building was not available. The CHP provides electricity for the building and supplies heat to the buffer tank.
- Wind turbines: There was not enough space on site, with enough clearance from obstructions to make a wind turbine feasible on the sight. This was omitted from the proposal.
- Heat pump: To supply the building with an efficient sustainable heating system an air source heat pump was selected. This takes most of the heating load of the building and the other systems mention above supplement the heat pump. This is also a very good system to demonstrate on site.
- Stove: To demonstrate the effectiveness of biomass we included a small solid wood burning stove. In the garden we are going to cultivate willow which will be coppiced, and the timber will be burned in the stove so that we can demonstrate how much forest is required to heat the building.

Conclusions & Recommendations

The overall conclusion rom the WISER LIFE project is that reusing building materials is very challenging primarily as it not a conventional way of doing things. The business of designing and constructing buildings in Ireland is not yet focused on material re-use. On this project this was evident in the following:

- The Boiler House and the Ballymun flats were not designed to be disassembled in a way that the materials can be re-used.
- Buildings tend to be demolished in a way that reduces the material to a very low value very quickly.
- There is no market for re-used materials because the value of the material is low. It was very difficult to source material.
- It is difficult to find stores or stockpiles of re-used material and the availability of material depended on timing and having a wide network of contacts looking for your specific material.
- Leaving buildings empty, unused and unmaintained makes them more difficult to re-use.
- Storage is required to collect materials for large building projects.
- There is no benefit to contractors or designers in specifying re-used materials.
- There is no credit for reducing waste and it is not measured.
- It is difficult for design teams to specify re-used material and be able to certify the building on completion.
- Re-used materials do not come with CE certs or declarations of performance and it is difficult to assess the performance or quality of the material.
- It is more difficult for the contractor to find suppliers and sub-contractors for non-standard materials. For example, the range of Hemp suppliers and installers were very limited.

However, this project has also demonstrated that there are greater opportunities for re-use in the construction industry. Most importantly, we have demonstrated that building structures are adaptable and reusable, and the performance of the building fabric and finish of an industrial building can be improved to a very high standard.

We would make the following recommendations to increase the capacity and opportunity for re-use in the construction industry:

- Elements of the building structure that have a long-life span should be designed to be flexible and adaptable to ensure that they survive for the long term and are not demolished prematurely. They should be seen as valuable parts of the local infrastructure.
- Design for deconstruction could increase the ease, speed and cost of deconstruction and would increase the value and supply of the materials.
- Keeping records of building materials used increases their ability to be re-used.
- The benefits of reducing waste should be considered when specifying or using re-used materials.
- Re-used materials can be beautiful, useful and interesting.