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Report on deconstruction of a single storey hall for reuse

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Deliverable: D7.1a Report on deconstruction of a single storey hall for reuse

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Executive summary

This report is part of Deliverable D7.1 of PROGRESS project. It covers pre-deconstruction audit, steelwork deconstruction and demolition of the remaining parts of a single storey steel building (SSB).

A suitable SSB to become a test case to demonstrate the recommendations from Work Package 2 was found in Cologne. The hall was built in the beginning of 2000. The project contained steel components and concrete based parts. The hall itself was a steel structure while remaining parts on and below the ground were made of concrete.

The structure was surveyed by UAV device. The SSB is built of 7 different parts. From up to down the hall consists of the roof insulation build out of styrofoam with a foil, the roof itself made of trapezoidal sheets, a secondary steel structure connected to the primary frames. The steel construction is founded on a reinforced concrete plate. The plate and abutments are located approx. 1.0 m above the ground. The space in between is filled with sand or any other material suitable at the original building time.

Costs and working hour information were collected to get results on how much extra costs are derived due to deconstruction for reuse.

The project was selected as an example to demonstrate that deconstruction for reuse is possible even for projects primary announced as demolition projects. The deliverable shows clearly, that the costs for deconstruction are acceptable and reuse is an additional option making the extra effort worth for all relevant parties.

The possibilities to perform deconstruction with the same machines as the regular demolition were also tested in this study.

The pre-deconstruction audit report based on the Deliverable D2.1 of the deconstructed SSB is attached to this report as Appendix.

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1 Introduction

The goal of this study is the verification of the theoretical research in WP2 in a real-life case. The possible object needs to fit the earlier description of a modern single storey hall, should not be older than 25 years and the cladding should be made of sandwich elements.

Typically, single storey halls are not built as temporary objects. Although costs for building are lower compared to concrete structures, today's buildings are not typically intended for reuse. Nevertheless a perfect single-storey steel building (SSB) was found in Cologne. The owner had to remove a single storey hall from the area of the great market in Cologne. His intention was just the clearing of the area as he was committed by contracts with the operator of the market area.

For the practical reasons, a compromise needed to be found between traditional demolition with the advantages such as little costs and high performance and new technologies which intend the reuse of the whole building.

Additional goal was to explore a technology based on machines which are typical for demolition work and to perform a deconstruction with them. The use of the standard demolition machines is helpful because it opens the possibility to switch from deconstruction to demolition extremely fast. Even for projects not intended for deconstruction during planning this might open the possibility to optimize the project for reuse on a later stage.

1.1 Overview of the project



Figure 1 Area of the great market of Cologne with the object to deconstruct for reuse

The great market of Cologne is an area, where different sellers of food and fruits store imported goods for reselling to companies, restaurants, and general food stores (Fig. 1). The area consists of many buildings and halls from all decades. The great market itself is not operating as seller itself. It generates the framework for other companies, which are selling the goods. The idea is to have all the big players of imported fruits on one place. Most of the larger cities in Germany have such markets for almost a century. Nevertheless, today there is little need for the idea of such centralized market. Thus, the market area in Cologne is closing during the next years and first companies are leaving the area already today.



Figure 2 View through the market area with the single storey hall to be deconstructed on the right.

Especially the bigger companies were running out of space somewhere in the past and built additional storage halls to extend their capabilities. Unfortunately, when leaving the area they are contracted to remove “own” buildings.

The result is the need to remove even relatively new buildings which are perfectly reusable.

2 The hall in Cologne

2.1 Surveying the structure

In most cases for objects to be demolished there is a lack of information. The original building plans do not exist anymore after some decades and the change of owners. In most cases, there is no information about materials used, possible hazardous waste (which in general was unknown to be hazardous in older times) and no drawings of the formerly planned building.

Survey of materials and even chemical tests of mineral waste is common and necessary due to the risk to contaminate the environment or risk health of people. To create drawings of buildings to demolish is usually not worth the effort. Nevertheless, exact geometry knowledge could be very helpful for the planning of a demolition project.

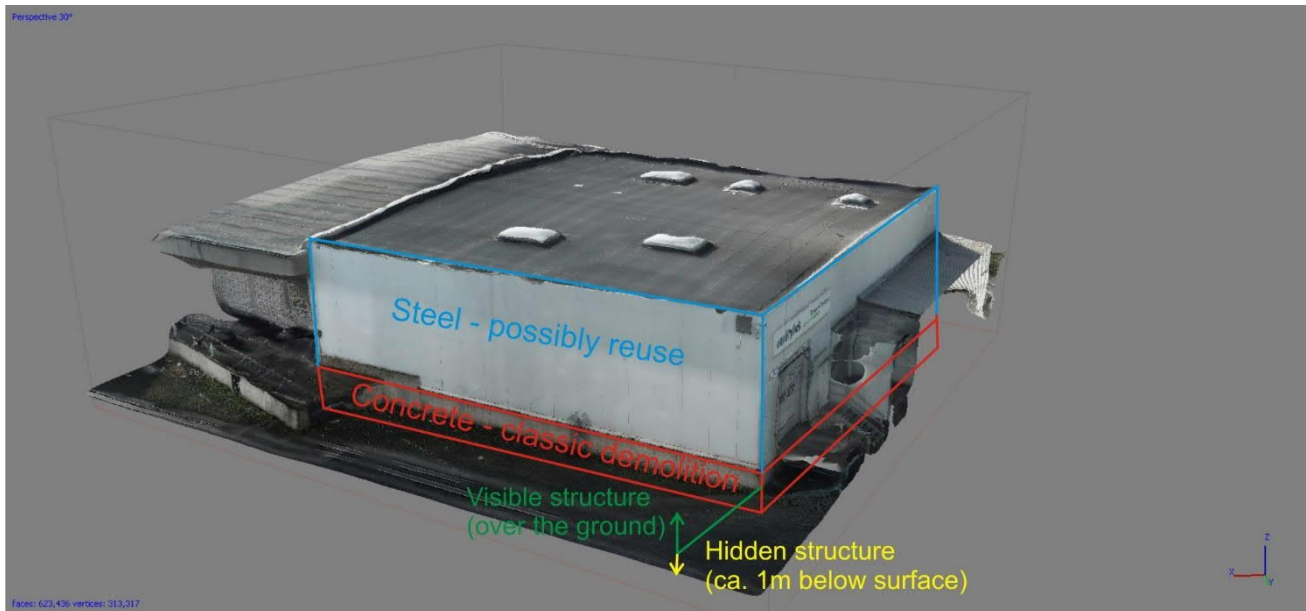


Figure 3; Overview of the SSB on a UAV model: The hall consist of a visible over the ground structure which is made of steel with attached cladding (blue), a concrete structure which ends ca. 1m below the surface (red).

During the planning of the work, the steel structure was identified as a possible reusable item while the concrete founding are to be demolished. For the crushed concrete, there is a general possibility to downcycling and reuse the material as recycling-gravel. This is obviously the lowest form of recycling.

The concrete structure is mainly unknown. From general experience it can be assumed, that floor plate and walls were made of 20cm reinforced concrete. The space below the floor plate is assumed to be filled with sand or a similar filling. For calculation, a box with no holes and no empty spaces is assumed.

The steel-work is easier to survey. While the roof is made of trapezoidal sheets with insulation, the primary structure consists of 4 frames made of 2 parts which are connected in the middle axis. The frames are made of non-standard steel beams. The secondary structure is made of small beams. It was planned to deconstruct the primary and secondary structure. The trapezoidal sheets and the

cladding are not recommended for reuse possibilities since a deconstruction of the light-weight parts is very time intensive.



Figure 4: Steel structure: The primary structure is made of 4 steel frames. There is no visible connection plate on the ground. Obviously, the columns are grouted with the concrete.

Table 1: Calculated masses and parts

1	Roof	531	m ²	Recycling, disposal
2	Wall (steel)	414	m ²	Recycling, disposal
3	Ground plate	106,2	m ³	Recycling off-site
4	Foundations / walls (concrete)	55,2	m ³	Recycling off-site
5	Filling	630	m ³	Based on chemical quality
6	Reusable structure	20	t	Deconstruction reuse



Figure 5: Between each of the frames smaller cold-formed steel beams as a secondary structure are visible. The connections are screwed.

Table 1 lists the main parts of the objects from the roof down to the foundations. In general, the concrete and filling are about 700 m³ / 1.500 t. The steelwork with cladding is approximately 50 t only. Even if the structure is going to be reused, most materials of the building are still becoming waste.



Figure 6: Inside there are 2 rooms. The walls between those rooms were made of cladding walls.

The height of the hall is below 10 m. That means, that the machines used for demolition may be used for deconstruction as well. This is important to switch during the work process between parts to deconstruct for reuse and concrete demolition work without changing the machines used. As a test case this opens up the possibility as well for projects not initially intended for reuse to deconstruct parts if it suits.

2.2 Additional object information

Besides the exploration of a structure all known information are collected. Especially on industrial sites it is urgently important to collect data about bombings due to World War II. Close to the building a probably not-exploded bomb was detected. Also, exactly at the position of today's hall, a German gun emplacement was located. The bomb itself is not affecting the demolition of the hall – the distance will not become closer as 30 m. Since the hall was built around the year 2000 the former gun emplacement was already known at times of building the hall. During earthwork at that time possible remains were already removed.

The following illustrations Fig. 8 and Fig. 9 show the original results from the German authorities on possible leftovers from World War II for the area of the demolition project.

The result of the analysis of leftovers is, that there is no danger due to the found unexploded bomb as well as there is no need for further local investigations. Nevertheless, work below the ground-level should be done with care.

While the finding of a World War II leftover doesn't affect the deconstruction / demolition project itself, the possible bomb will be investigated by authorities soon.

2.3 Boundary conditions: Sewer pipes

Any building is connected to the sewage system in the ground as well as to electricity and other services. It is evident that a building to remove needs to be cut from all the service systems before the demolition. The connection to the sewer system needs to be sealed to prevent pollution of the sewer system with ground material causing blockage of the sewage pipe.

The owner of the sewage system postulates a partly removal of the sewer system as well as sealing of the connections with concrete. The sewer system of the area is well documented (Fig. 7)

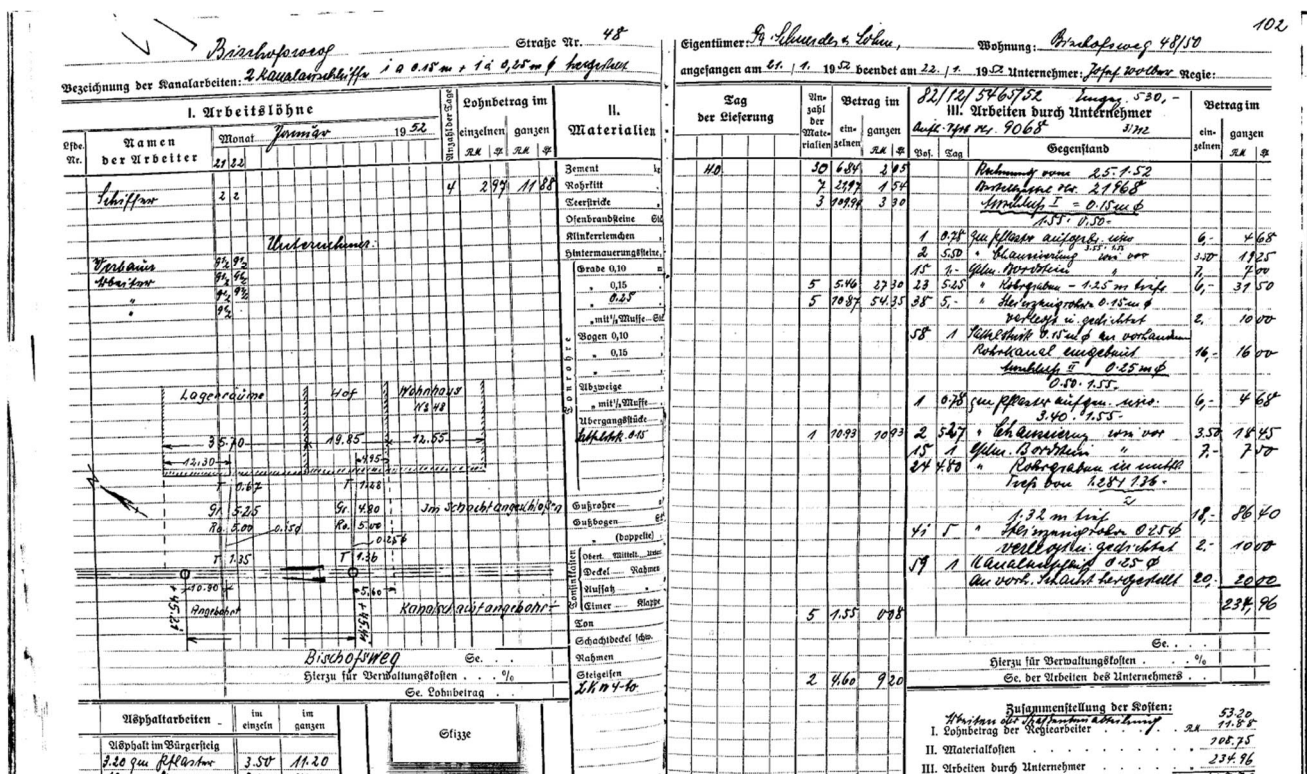
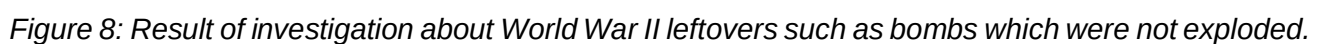


Figure 7: documentation of sewer system from 1952.





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Projekt Bischofsweg 48a in Köln Rondorf (Gmkg. Rondorf, Flr. 53,
Flrst. 2075)

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Punktnummer 3670

Rechtswert 356051,33

Hochwert 5642310,13



Figure 9: Exact coordinates for a possible bomb from the times of world war II.

2.4 Calculation of waste

Any demolition project needs detailed calculation of the possible waste and information about the possible disposals. If possible, recycling plants are preferred.

Table 2: Calculated potential waste of the SSB

waste, not dangerous starting from 1 to / 1m³				
AVV	name		mass	type
170101	Concrete	☒	600	to
170102	Brick	☐		to
170103	Tiles, ceramics, brick	☐		to
170107	Mixture of above	☐		to
170201	wood (not painted All)	☐		to
170203	plastics	☐		to
170302	Bitumen	☐		to
170405	metals, steel	☒	60	to
170504	earth, natural stones	☒	600	to
170604	insulation	☒	10	to
170802	Gypsum	☐		to
170904	other waste	☒	40	to

Waste, dangerous				
AVV	name		mass	type
170106	Mixtures of concrete, bricks, ceramics with dangerous contaminations	☐		to
170204	Wood, plastics and glas with dangerous contaminations	☐		to
170301	bitumen polluted with tar	☐		to
170303	products containing tar	☐		to
170503	Earth, natural stones contaminated	☐		to
170601	insulation containing asbestos	☐		to
170603	dangerous insulation	☐		to
170605	asbestos	☐		to
170801	contaminated gipsum	☐		to
170903	other waste contaminated	☐		to
170902	waste polluted by pcb	☐		to

In summary, the object of a SSB in Cologne can be divided into 5 different waste types. The total steel was calculated to be up to 60 t including the sheets from the sandwich elements used as cladding. The total constructional elements would be about the half of the total used steel. The main waste will be produced from the concrete parts of the hall and the filling below the ground plate. Insulation and general waste (for example the sealing of the roof) are calculated to be up to 50 t and therefore more by weight than the total steel.

The list of possible waste is not giving information about the reuse potential, because it is not part of the German protocol for demolition. Thus, for the planning all potential kinds of waste have to be declared.

3 Deconstruction of the hall by excavators

3.1 Idea of excavator-based deconstruction

Generally, demolition is excavator based while deconstruction is based on lifting parts up. In easier words: Demolition is a technique to destroy a building or hall controlled and sort the masses into classes of materials. Deconstruction needs to survey the former elements. While during demolition connections of steel beams can be cutted with the help of the excavator (e.g. steel shear devices), a deconstruction project needs the connections to be unscrewed. Thus, an excavator seems not to be the right instrument for deconstruction.

On the other hand, after deconstruction of the steel parts an excavator is needed to remove the concrete basement parts. That means, that even a deconstruction of all reusable parts ends in traditional demolition of concrete based parts. Today, the removal of halls or other buildings is mostly entitled as a demolition. Thus, the contract of the client only describes the total removal of a specific object but does not describe the technique. The contractor owes the removal of the object in a given time span. Mostly, the contract will not specify that the former object has to be destroyed and become waste. Thus, it is up to the contractor how he plans to remove the object. Deconstruction is only an alternative, if the deconstruction can be performed fast enough to follow the given time span for the demolition project. To minimize costs of the extra work for deconstruction it would be a good to use the same machines as for the demolition. Then, a deconstruction could be performed as an alternative with the later chance to sell the reusable parts.

The less additional machines are used, the better the deconstruction can perform against the demolition.

For the Cologne SSB the deconstruction by excavators was tested. As a first step, the different parts of the SSB were analyzed if deconstruction would be an alternative to demolition.

3.2 Analysis of parts to be deconstructed

The SSB is built of 7 different parts. From up to down the hall consists of the roof insulation build out of styrofoam with a foil, the roof itself made of trapezoidal sheets, a secondary steel structure connected to the primary frames. The steel-based construction is founded on a reinforced concrete plate. The plate and fundaments are located ca. 1,0 m above the ground. The space in between is filled with sand or any other material suitable.

The deconstruction causes higher costs. Thus, it is important that parts are suitable for reuse after deconstruction. If they fail to be reused, those parts would be handled as waste / recycling materials only with the same effect as generally demolished parts. That means, that only those parts shall be deconstructed, which are not predisposed for deformation during the deconstruction process. Trapezoidal sheets are not deconstructable without deformation as well as sandwich elements could easily be damaged. Thus, it was chosen to deconstruct the primary and secondary structure while demolish the light-weight parts such as the cladding and the trapezoidal sheets.

Table 3 lists the parts and the decision about the handling for the test case. Figure 10 shows the deconstruction plan.

Deconstruction of a SSH

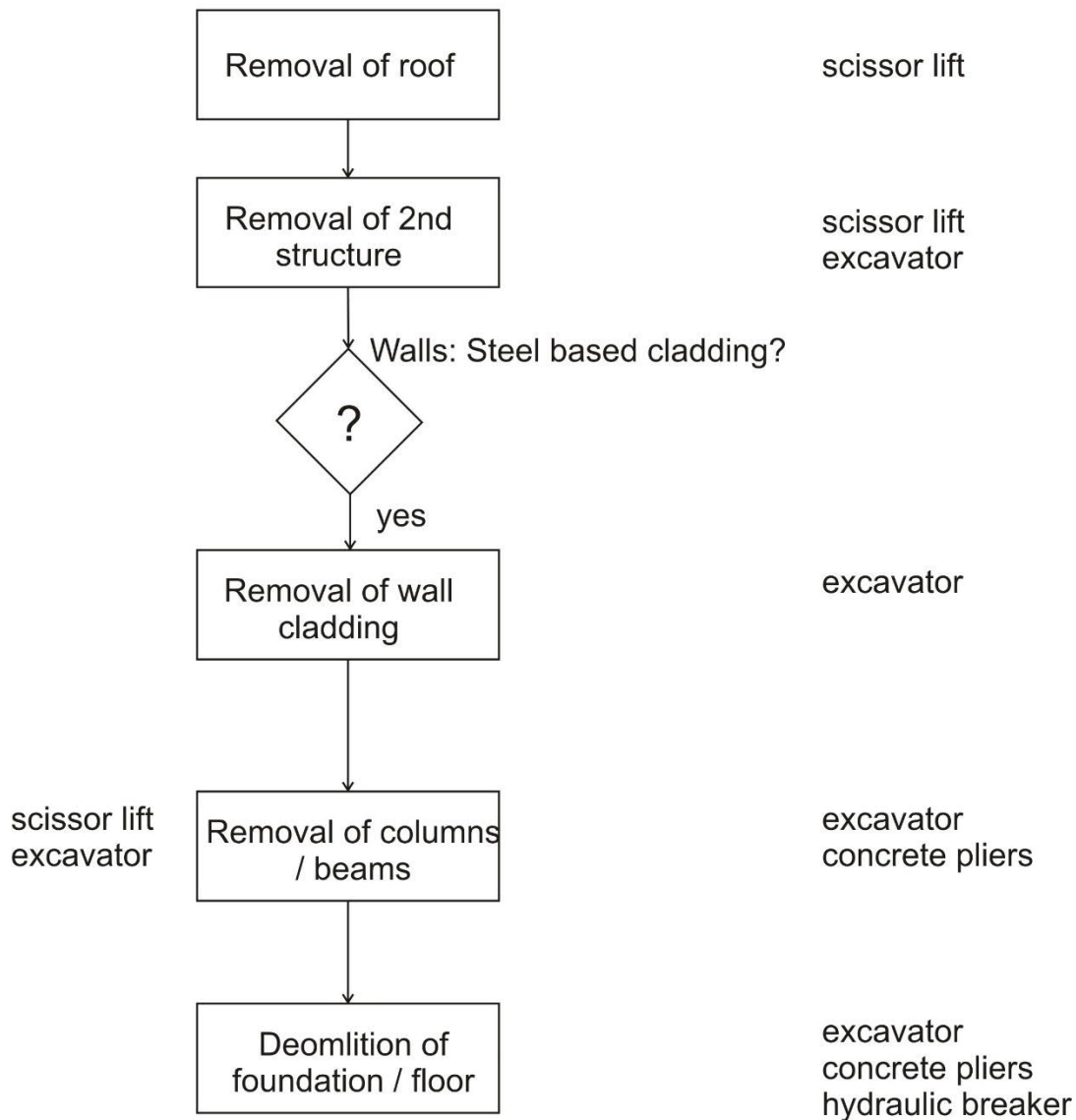


Figure 10: Deconstruction of the Cologne SSB by excavators. The primary and secondary strucutre is deconstructed for reuse. Cladding and light-weight materials are chosen for recycling only. Foundation is handled as regular demolition.

Table 3: List of parts of the SSB and decision of deconstruction vs. demolition

Part	Description	Demolition	Deconstruction	Comment
Roof insulation	Foil with insulation of styrofoam		(X)	Manual removal. Possible reuse but no market for used insulation parts
Roof	Trapezoidal sheets	X		Tends to warp. Potential of deconstructed parts to fail for reusing.
Secondary structure	Steel beams, screwed		X	parts can be unscrewed. Lifting by excavator
Primary structure	Steel frames, screwed but grouted into concrete		X	Uncovering old connection plates
Side walls	Sandwich elements	X		Tends to warp. Potential of deconstructed parts to fail for reusing.
ground plate	reinforced concrete	X		Monolithic part. Only available technique.
Filling	Sand, earth or equal	(X)		No structure. Only waste-management needed

3.3 Dismantling of structure by excavator

For general demolition of an SSB the safe technique for demolition of the structure is given in fig. 11. The technique is based on flame cutting the adjacent girders and pulling the structure down. If the primary structure is poured in concrete, there exist cutting techniques to create a hinge that allows the needed movement.

Further in the project, it will be checked, if the connection can be uncovered so that flame cutting will become evident.

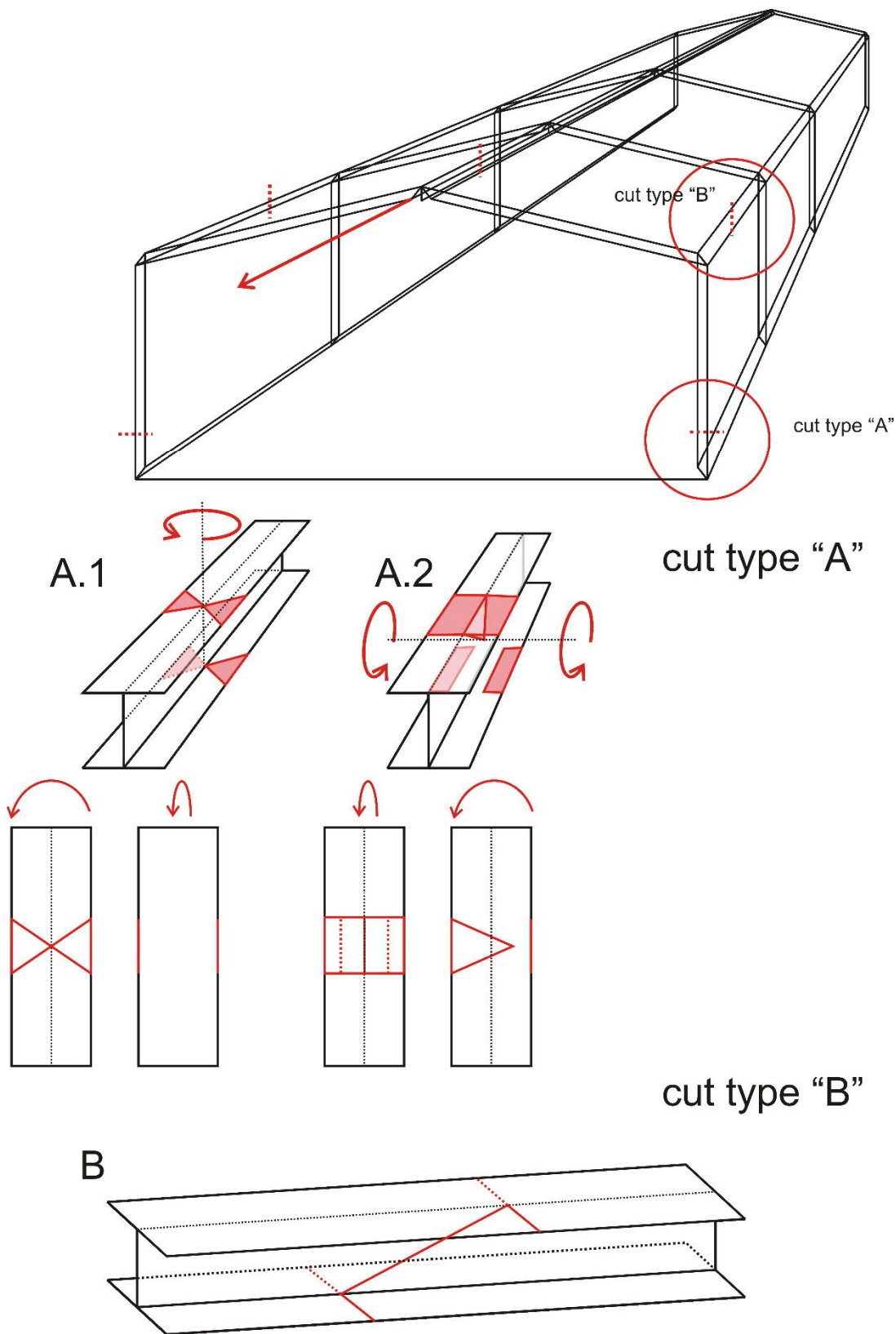


Figure 11: Combined technique to dismantle the primary / secondary structure for demolition.

In fact, the technique is the same for deconstruction, except that no flame cutting is used. Instead the joints need to be unscrewed. The poured parts have to be dismantled by small excavators. It is evident

not to release joints of the secondary structure before the anchoring in the ground. As well, deformation may become an issue. Thus, it is recommended to use two excavators for laying the frames on the ground.

3.4 Documentation of deconstruction / demolition

Any deconstruction or demolition follows the top-down principle. Halls in general are removed from the outer parts to the bearing structure. That means, after the deconstruction of the roof and the walls, the secondary and primary structure is dismantled. After the total removal of the steel based hall the demolition works of concrete parts follows. In the end, the filling will be transported away. Preliminary, the filling will need to undergo a chemical analysis.

3.4.1 Roof



Figure 12: Removal of roof insulation and sealing; Left picture before removal

Modern roof structures are insulated by a 30cm or more thick insulation of styrofoam. Removal by machines causes parts of the styrofoam to be destroyed and being blown away. To avoid the waste to be blown away it is recommended to remove the insulation by manual work. After the insulation removal, above the trapezoidal sheets all non-steel materials are deconstructed.

3.4.2 Removal of cladding

After the insulation of the roof the side walls were dismantled. During the dismantling by excavators with an attached gripper it was tested, whether the sandwich elements can be dismantled without damage. Thus, it was tested, if those elements were usable for reuse. In fact, the gluing between the metal sheet and the insulation was weathered so much, that the connection was not stable anymore. Some parts were transported to RWTH Aachen to undergo more technical tests. At least, the metal sheets were separated from the insulation. This separation helped to lower the total mass of general waste and increase the steel, which could be recycled.



Figure 13: SSB with removed roof insulation and removed walls of sandwich elements. On the right, an excavator is starting to separate the metal sheets from the inner insulation of the sandwich elements.

For separation the following technique was invented:

- 1) A Single element is laid down the ground.
- 2) The excavator grips one corner and pulls the metal sheet up. While pulling the sheet up the weight of the element is used to separate the metal sheet.
- 3) Two workers remove parts of insulation which adhere on the sheet.
- 4) The separated materials are sorted into metals and general waste.

Figure 14 shows the dismantling by excavator without deforming the sandwich elements. It was determined that separation of the different materials is best function, if the elements are not badly brought up but mostly in shape. Figure 15 illustrated the process of separation.

Thus, although in this example the sheets could not be reused, in general a dismantling technique open for reuse is recommended for the sheets. Even if reuse seems not practicable separating the materials will be easier if the elements are not deformed yet.



Figure 14: Dismantling of sandwich sheets. Testing of reusability. Technically, safe dismantling is possible by excavators. Reuse might not be recommended since the glue between metal and insulation is weathered. Besides, the metal sheets have many holes e.g. from attached lamps, signs and other inventory attached to the sheets.

After removal steps 1 and 2 the hall is left as a steel structure without any walls and the roof by trapezoidal sheets. The further dismantling has to consider the special geometry. The steel-based structure is connected to a concrete slab, which is located on metre above the ground for easier access to trucks. For the deconstruction of the structure the excavators are moving forward and shall remove only the trapezoidal sheets from the next axis to dismantle. Before removing the primary structure, the secondary structure needs to deconstruct. After deconstruction of each axis, the platform of concrete needs to be demolished.

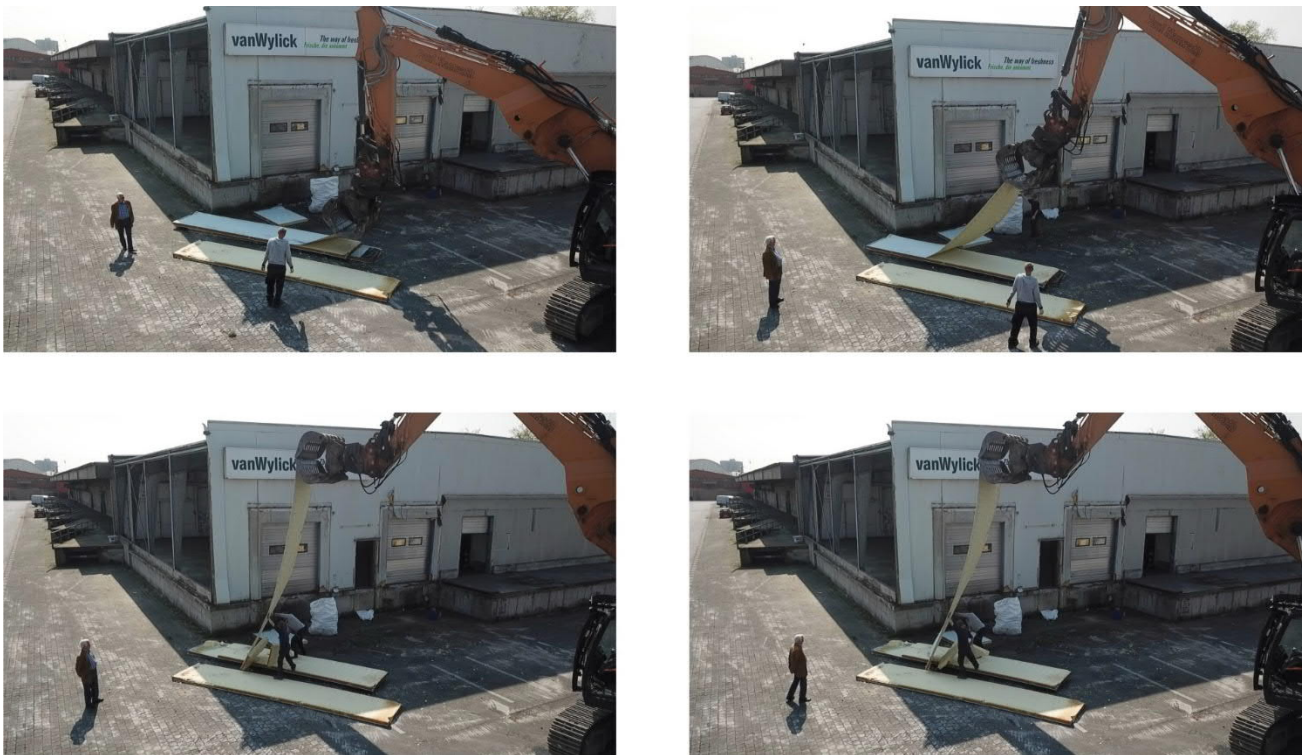


Figure 15: Separation of metal sheets by help of excavator and two workers

3.4.3 Preparation for deconstruction of structure

The main advantage of excavators in opposite to dismantling structures by hand is the better efficiency. Trapezoidal sheets are very light weight compared to the secondary or primary structure. If the sheets are not needed anymore the use of an excavator avoids unnecessary unscrewing of the sheets. In fact, screws will burst if the excavator grabs a sheet. Because the sheets are much thinner than any structure, no parts of the secondary or primary structure are affected. In fact, it seems that the excavator just pulls off the sheets without any resistance.

At this stage, most materials from the object became waste. All metals became part of the recycling process and are put back into the cycle for re-melting. All insulation was used for energy recovery – in other words the styrofoam was burned and only used as energy source.

But, at this stage no parts were put back on the market as reusable parts. The reasons, why no parts were suiting the idea of reusing were:

- 1) Thickness of flat parts. Parts to be reused should be able to be handled without too much care. If parts tend to deform the chance is high that a certain percentage does not fit the claim of later reusing. If the parts are sold later for reusing but are not reusable due to deformation, they might be returned. The effort to deconstruct parts with zero deformation would be higher than the costs for generally new parts.
- 2) Especially the cladding on walls and roof are used during the first life for connecting certain building equipment parts to it. That causes changes in original colour, holes from connections and scratches to the sheets. While the bearing structure is mostly as on the first day of usage, the metal sheets look used. Reusing means that the whole SSB never will fit the definition of a new building.

- 3) It remains an open question, who will be responsible for deformations. If the former SSB was sold as one piece of reusable hall, each deformed part can cause claims by the buyer for a additional part which is free of deformation. Unfortunately, the risk is high to be responsible for the costs of those additional parts.
- 4) Even if just dismantled parts are sold, which may fit or not fit the needs for reusing, a price above the price of general scrap metal is only possible, if the percentage of not-deformed parts is at least 90%. To reach such a high percentage of intact parts, the efforts is becoming very high which may result in prices not in line with the market.



Figure 16: Dismantling old trapezoidal sheets just before deconstruction of structure.

After the removal of the trapezoidal sheets the structure remains. All parts up to this stage were sorted and were planned to recycle. The structure now will be the part which is carefully dismantled and not become waste but shall be reused. Mainly, in this stage there are 2 kinds of waste: Steel coming from the sheets and the cladding and styrofoam as filling of the wall cladding and as part of the roof insulation (see fig. 17)



Figure 17: Sorted waste for recycling. Mixture of trapezoidal sheets and sheets from sandwich elements.

3.4.4 Dismantling secondary and primary structure elements

The secondary structure is made of small beams with a diameter of 8 cm. Dismantling them by excavator can cause deformations while any manual deconstruction by workers is safe. Thus, the dismantling was done by scissor lifts and workers. The excavator was used as a crane only to lift up the parts. Besides, the excavator prevents parts from falling down.

To obtain stability, only the secondary structure between two main frames is dismantled. After the removal of a main frame, the secondary structure between the next fields is removed.

Figure 18 illustrates the dismantling procedure: The excavator is used as a crane with chains to prevent unwanted falling of the part. Workers release the connections of the beams to the primary frames. After releasing all connections, the beam is lifted and removed.



Figure 18: Dismantling of secondary structure. These parts are still too thin, that handling with an excavator only would result deformation. On the other hand, these parts are not tending to deform as long as dismantled manually. In opposite to the cladding, only five elements between each section are to dismantle.



Figure 19: The hall during the process of dismantling just before deconstruction of the structure. The trapezoidal sheets are being removed by 50%. Only the structure is remaining. After the removal of the trapezoidal sheets all remaining steel parts are considered for reuse.

Generally, the deconstruction of parts is mainly done by cranes. For the test case it was chosen to use excavators. On the one hand, excavators are the typical machines for demolition and are multifunctional. Excavators can be used not only to lift things up but also with attached tools to remove concrete, to load materials and to separate waste.

If excavators are planned to be used, they are limited by height. If the object is larger than the height of the excavator, a deconstruction by excavator work will fail. The possible height of excavators already reaches 50m and more. Beside those special machines standard excavators reach ca. 15m in height. That matched most SSB.

Nevertheless, the higher the distance between the structure and the excavator, the little horizontal forces are (see. Fig. 20). Especially if the frame is made of connected parts additional forces should be avoided. It was chosen to pull the frames down by two parallel working excavators.

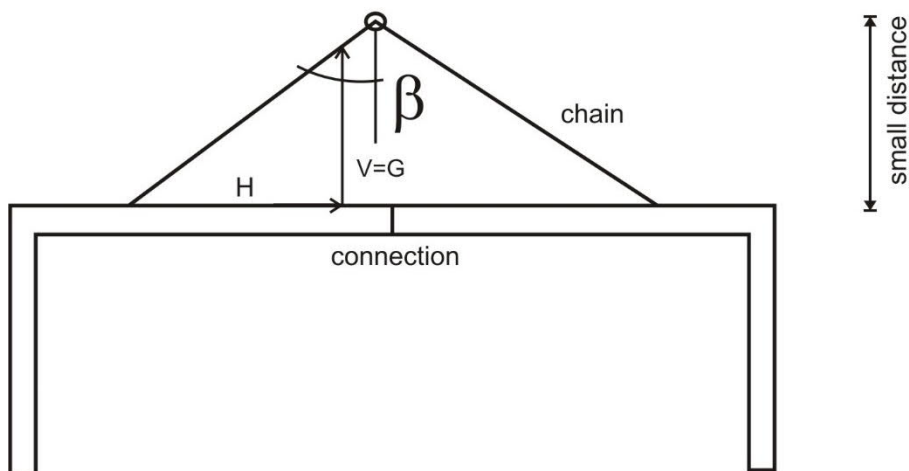
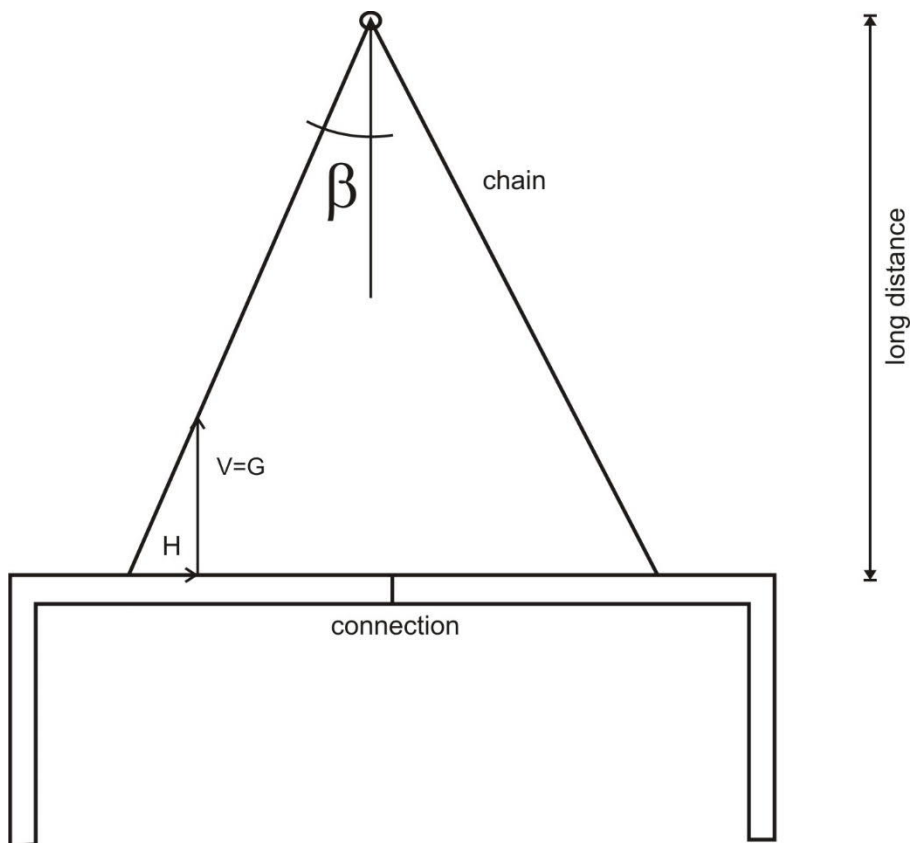


Figure 20: Forces in dependence to the vertical distance of the crane. The smaller the distance becomes, the more horizontal forces arise. It may affect the connections so that other techniques are needed instead of classical up lifting by excavators.



Figure 21: To avoid instabilities, two excavators carefully pull down the structure to the ground.

Figure 21 shows the solution: Lifting the whole frame up by one excavator would affect the connection point in the middle of the frame and is not recommended. Instead two excavators were used with grabbers to slightly pull down the frame. On the ground, all connections were released without the danger of collapse of parts of structure.

Before pulling the frame down, it was important to explore the connection of the steel-based frame to the concrete floor. From first explorations it was known that the steel frames were not having plates on the concrete plate but were shed into the concrete.

Figure 22 and 23 demonstrate the anchoring of the steel columns. After creating the fundaments, the construction of the steel frames was set up. When the primary / secondary construction was finished, the floor plate was made. The anchoring points were hidden underneath the concrete. During the planning it was discussed to cut the steel just above the concrete slab. That would cause that the reusable hall will be some smaller than before. After the exploration of the connection all anchoring points were uncovered so that the parts kept their original length.

The uncovering of the anchoring points resulted in temporary instability of the hall if no device was preventing tipping. Thus, while at least one excavator was stabilizing a frame, the anchoring points were uncovered only for the frame to pull down.



Figure 22: Removing concrete at jointing of steel frames. The steel connections was shed below the floor plate directly on the fundaments. Afterwards the connections was shed into the concrete of the floor plate. To release this connection, the concrete was removed partly around the anchoring.



Figure 23: View from the downside of the connection. The plates were connected to the fundamentals and shed into the concrete of the ground floor plate.

3.4.5 Demolition of mineral based parts

After the careful deconstruction of the structure only the parts not made of steel were left. The complete removal of the hall includes the demolition of those parts as well. The increase of the ground plate compared to the general ground was filled with sand.

Unfortunately, the sand was contaminated by PAK (tar) and reused from somewhere else instead of being a clean material.

Below the sand filling there exists still the old pavement from the times before the hall was created. This pavement was not removed, so that today you will find a pavement as 25 years ago again.

The figures 24 and 25 give an expression of the demolition of the ground parts. In the end any traces of the former SSB are gone.



Figure 24: Demolition of concrete slab and removal of sand filling. Below the old pavement was recovered.



Figure 25: Area of the SSB afterwards. The site is cleaned up.

3.5 Calculation of extra costs for dismantling structure

3.5.1 General costs of removal the SSB

The removal of modern SSB is not expensive. In fact, an SSB consists of little materials only, is mostly light-weight and mostly there are no contaminations like asbestos etc. Thus, for the given example the costs were 62.174€. About half of the costs were loans for workers, truck drivers and other people involved into the removal (32.979€). The second half of the costs included the waste management – the costs for concrete, general waste and disposal of the sand which was used for the filling underneath the concrete slab.

Table 4: Costs of the removal of the SSB

Removal costs	
Workers, machines	32.979,50€
Waste management	29.194,66€
Total costs	62.174,16€

The costs of work are separated in demolition work, the additional deconstruction work and the costs for separating the sandwich sheets and cleaning. Demolition and Waste management are quite the same with 13.664€ for demolition and 12.275€ for waste management. The additional costs for deconstructing the structure by scissor lifts, unscrewing on the ground, making the parts etc. were 7.039€. The additional costs were little because the machines planned for demolition were used and no additional “deconstruction only” machines were involved. The goal was to perform deconstruction by minimized costs and with the help of excavators to use this technique as alternative. In fact, the result is very nice if the additional costs are only half of the general demolition and / or waste management costs. The additional costs for deconstruction are about 1/5 of the total work-costs and little more than 10% of the total costs. Thus, deconstruction of structure can compete market conditions.

Table 5: List of work costs for Demolition, additional deconstruction and waste

Costs of work	
Demolition	13.664,86 €
Deconstruction	7.039,47 €
Waste management	12.275,17 €

32.979,50 €

The view on table 6 shows the costs of waste management including costs for disposal or recycling plants. Since the filling sand was slightly contaminated the main costs were for disposal of this sand. General (burnable) waste is of high costs always and mainly shows the immense costs of styrofoam which is not recyclable yet. Steel does not produce real costs except some leftover of transportation while concrete still is one of the lowest costs per ton.

Table 6: Costs of Waste management

Costs of Waste management			
Concrete	520,18	to	4.768,58 €
Earthwork / sand	849,24	to	14.935,15 €
General waste	37,53	to	8.686,85 €
steel	38	to	804,08 €
29.194,66 €			

The removal of the SSB took 688 hours “work” including general workers, truck drivers, excavator drivers. Comparable to the costs about 20% were the additional time for deconstruction instead of total demolition. Demolition took slightly more than waste management but still both actions are comparable by time.

Table 7: Working hours

Working hours		
Demolition	304,70	h
Deconstruction	156,97	h
Waste management	226,83	h
688,50 h		

3.5.2 Reuse of cladding

As written above the wall cladding was removed as if these parts were planned for reusing. The reason was just the separation of metal sheets. Nevertheless, due to the careful dismantling of the cladding it was possible to calculate costs comparing two cases: Deconstruction of cladding and reuse against demolition of cladding and buying new cladding for the hall to be reused.

If all the sandwich elements would be recovered without any transformations to the sheets, reuse would be cheaper than demolition and buying new cladding, even although the costs for deconstruction are much higher than demolition (see Table 8 deconstruction 15,84€ / demolition 3,5€; but: total costs 19,34€ for deconstruction / 23,40€ demolition).

Starting with a loss of 20% of the deconstructed elements the idea of reusing would produce higher costs than demolition with new cladding. That means, if during a deconstruction project including the

sandwich elements costs are cheaper as long as more than 80% of the deconstructed sheets would be in a condition to reuse those elements again. That means, mostly the reuse would be the cheaper possibility.

But, the aging effects of sandwich elements have to be taken into account. For the Cologne SSB the aging effects did not allow reuse of the sheets.

Table 8: Comparison of costs for reuse and renew sandwich elements for a hall to be reused.

costs of reuse cladding

Deconstruction				
Deconstruction of wall cladding		1 [m ²]		15,84 €
Transport, Warehouse		1 [m ²]		3,50 €
Total costs		1 [m ²]		19,34 €
Total w Loss / new 10%		0,1 [m ²]	2,59 €	21,93 €
Total w Loss / new 20%		0,2 [m ²]	5,19 €	24,53 €
Worker Deconstruction	16 [h]	160 [m ²]	42,00 € [€/h]	672,00 €
Scissorlift	1 [pc]	1 [d]		300,00 €
Crane, small	1 [pc]	1 [d]		640,00 €
Worker Forklift / Packaging	16 [h]		42,00 € [€/h]	672,00 €
Forklift	1 [pc]	1 [d]		250,00 €
				2.534,00 €
Demolition / New Cladding				
Demolition		1 [m ²]		3,50 €
Costs of new cladding		1 [m ²]		19,90 €
Total costs		1 [m ²]		23,40 €
Grabbing by excavator	4 [h]	600 [m ²]	144,00 € [€/h]	576,00 €
Separating	8 [h]	600 [m ²]	144,00 € [€/h]	1.152,00 €
Helper	16 [h]		42,00 € [€/h]	672,00 €
				-150,00
Income steel		4,464 [to]	€ [€/to]	-669,60 €
Costs of Waste		2,976 [to]	125,00 € [€/to]	372,00 €
				2.102,40 €

3.6 Quality-check of parts

All parts identified for reuse needed to be checked afterwards. In general, all parts suited the quality needed. No parts were deformed. Some screw holes were damaged during flame cutting. Flame cutting was used, if unscrewing was not possible due to rust, mechanical errors, or impaired supply of the threaded rods.



Figure 26: deconstructed parts of primary structure ready to be reused.



Figure 27: Detail. Connection of frames



Figure 28: Parts before transportation to the warehouse



Figure 29: Detail: Small damage due to flame cutting.

3.7 Measurements of dust

Solid particle counters are used to measure dry particles for various industrial applications. One such application could be for the detection of particle size coming from a rock crusher within a mining quarry. Sieves are the standard instruments used to measure dry particle size. Vision based systems are also used to measure dry particle size. With a vision based system quick and efficient particle sizing can be done with ease and tremendous accuracy.

There are several methods used for detecting and measuring particle size or size distribution — light blocking (obscuration), light scattering, Coulter principle and direct imaging.

The light blocking optical particle counter method is typically useful for detecting and sizing particles greater than 1 micrometer in size and is based upon the amount of light a particle blocks when passing through the detection area of the particle counter. This type of technique allows high resolution and reliable measurement (Fig. 30).

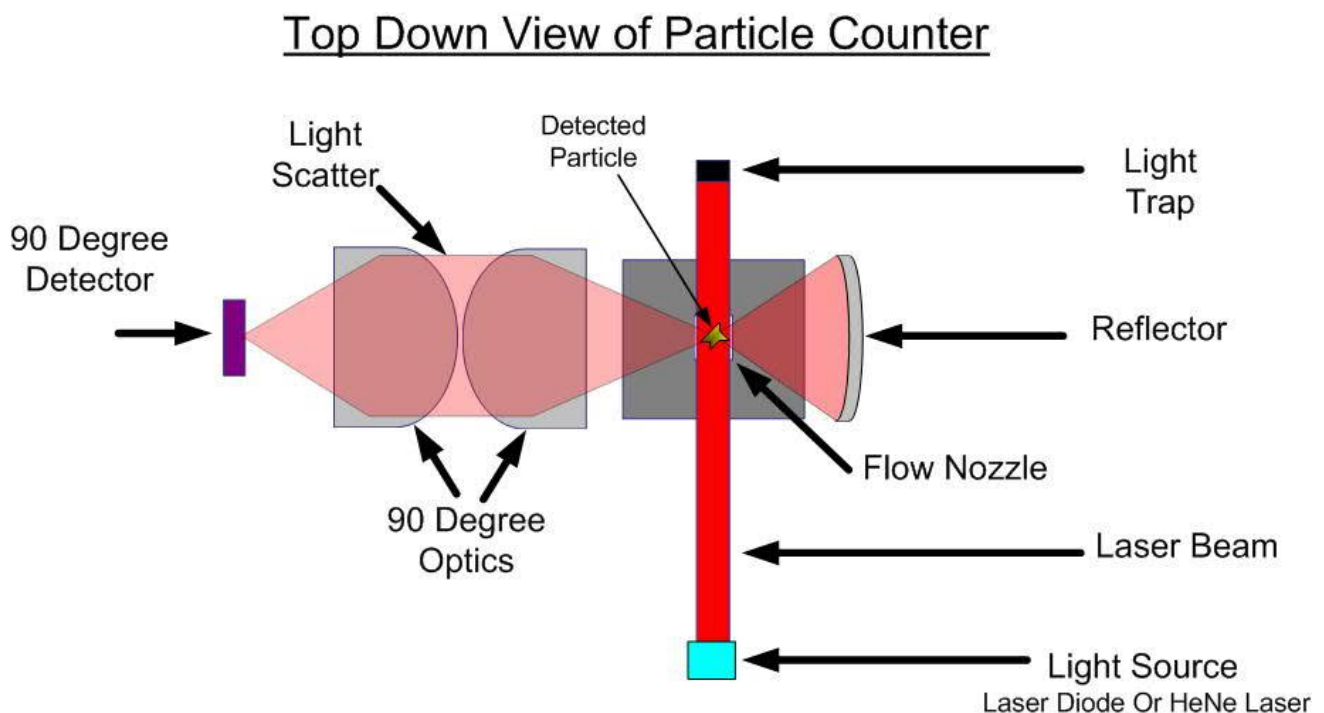


Figure 30: General scheme of a particle counter

The light scattering method is capable of detecting smaller-sized particles. This technique is based upon the amount of light that is deflected by a particle passing through the detection area of the particle counter. This deflection is called light scattering. Typical detection sensitivity of the light scattering method is 0.05 micrometre or larger. However, employment of the condensation nuclei counter (CNC) technique would allow a higher detection sensitivity in particle sizes down to nanometre range. A typical application is monitoring of ultrapure water in semiconductor fabrication facilities.

The light blocking method is specified for particle counters that are used for counting in hydraulic and lubricating fluids. Particle counters are used here to measure contamination of hydraulic oil, and therefore allow the user to maintain their hydraulic system, reduce breakdowns, schedule maintenance during no or slow work periods, monitor filter performance, etc. Particle counters used for this purpose typically use ISO Standard 4406:1999 as their reporting standard, and ISO 11171 as the calibration standard. Others also in use are NAS 1638 and its successor SAE AS4059D.

Direct imaging is a technique that uses the light emitted by a laser as a source to illuminate a cell where particles are passing through. The technique does not measure the light blocked by the particles, but rather measures the area of the particles functioning like an automated microscope. A pulsed laser diode freezes the particle motion. The light transmitted through the fluid is imaged onto an electronic camera with macro focusing optics. The particles in the sample will block the light, and the resulting silhouettes will be imaged onto the digital camera chip.

Especially for controlling conditions of clean rooms, small particle counters are on the market. These counters were tested now for indoor conditions of fiber contaminated rooms. In fact, the number of fibers / m³ are give an important information about the contamination. For asbestos a room is free of contamination if the number of fibers is below 500/m³. Exact measurement is expensive and not possible ion the air. Since fibers of asbestos are little a good possibility to control the conditions is a small particle counter. Since particle counters result in information of the number of particles of a specific size, this instrument can give an approximate feedback of the total number of particles in a room. The difference to regular measurements of asbestos or other fibers is, that particle counter do not differentiate between a fiber-particle and a general particle. It can be assumed, that particles smaller than 0,5µm could be fibers.

With particle counters originally created for controlling clean rooms (medicine reasons, electronical devices) there is a possibility to use results as approximate tests for contaminated rooms in buildings to demolish.



Figure 31: Particle counter with display.

First tests showed the following results:

1. The measured number of particles indoor is generally high and above 10.000 / m³.
2. A dusty room results in a measured number of particles > 1.000.000.
3. The use outside e.g. to control the dust produced due to demolishing a building is not given usable results.
4. A room cleaned up after the removal of asbestos and other fiber products shows particle numbers of < 2.500. This may be a sign that the work was following the guidelines.
5. Official measurement to declare a room as free of asbestos is still only possible by special measurement of asbestos.

Today, particle counters are helpful for self control reasons. Small numbers of particle are a sign of good work especially in contaminated areas. Measurement may become interesting for outdoor as well. Ongoing research is needed here.

4 Conclusion

A SSB suitable to become a test case was found in Cologne. The hall was built in the beginning of 2000's. The possibilities to perform deconstruction with the same machines as the regular demolition were tested.

The identification of parts which were deconstructed for reuse tried to estimate the risk of damage due to deformation. Thus, the primary and secondary structure was deconstructed while all light-weight parts were recycled only. During the deconstruction and demolition, it was realized, that the sandwich elements were aged so much over 20 years, that the glue failed on the connection of metal sheets and insulation was too bad for reuse. On the other hand, it was experimented, how separation of sheets could be possible on site.

Nevertheless, most waste masses are created by the demolition of concrete parts. The total masses only change little if reuse is applied.

On the other hand, if reuse is prepared with deconstruction techniques performed by excavators, the total costs are only little higher compared to general demolition. The additional time for deconstruction was only 20% higher than for a demolition without deconstructing parts. Thus, to increase the decision to deconstruct parts of modern SSB for later reuse, the later reuse has to be seen as an additional chance with low extra costs. This might help to start deconstruction as an idea performed even without having a special client or buyer. The risk of high costs is little. The chance to increase income of demolition of SSB due to selling reusable parts may justify more experiments.

From the practical view the deconstruction of light-weight parts seems the challenging thing in the future. Besides technical issues it is important to find a solution for the following question:

Who is responsible for parts which are not reusable after deconstruction due to deformation? What percentage of loss is acceptable? At the moment it seems difficult to put a hall on the market with only 75% of cladding. Additional, sandwich profiles undergo an evolutionary process and may not be the same some years in future as today. That could result in a higher percentage of parts which are needed to be renewed. On the other hand: Deconstruction of light-weight parts is even competing against new parts if about 20% loss is included. Besides the technical problems the reuse of light-weight parts is a legal question of acceptable contract conditions.

The main result is the possibility to perform deconstruction by excavators instead of cranes. Deconstruction for reuse becomes so something, any demolition contractor could do or at least try.

Nevertheless, planning becomes important. A view to temporary situations as well as a higher risk of collapse follows the deconstruction idea.

Annex A: sampling protocol of possible contaminated sand

Probennahmeprotokoll

Protokoll über die Entnahme einer
 Reststoff- / Abfallprobe

Paul
 Kamrath

Abbruchtechnik
 und Entsorgung
 Ingenieurückbau GmbH

① Allgemeines:

Probenbezeichnung	Füllboden Köln Bischofsweg				
Baustelle	Köln, Bischofsweg 48a				
Zweck der Probenahme	Einordnung des RCL-Materials nach LAGA / DK0				
1	Probennahmestelle	Material aus Haufwerk			
2	Witterung	sonnig, trocken, ca. 16°C			
3	Datum	29.04.2020	Uhrzeit	12:15h	
4	Art der Probe	Mischprobe			
5	Entnahmegesetz	Schüppe			
6	Einzelprobe		Mischprobe	X	Zahl der Einzelproben

② Entnahmedaten:

7	Entnahmetiefe	40cm tief aus Haufwerk			
8	Farbe	Braun-gelb			
9	Geruch	Eigengeruch			
10	Probenmenge	ca. 3,5kg			
11	Probenbehälter	Eimer			
12	Probenkonservierung	Luftdichtes Verschließen			
13	Bemerkungen				
14	Foto	 probe: Site: Reason: Where: Whether: Type of sample: Tool: Nr. Of samples: One mixture Depth: Color: Mass: Container: Sand filling from Cologne Cologne, Bischofsweg 48a Analysis of material following the German LAGA / DK0 classification Middle of heap sunny, dry, 16° Mixture of sand shovel 40cm brown / yellow 3,5 kg bucket			
15	Unterschrift	Paul Kamrath Ingenieurückbau GmbH Hamburger Str. 27, 44329 Dortmund Tel. 0231-579751/52 Fax 0231-579753			

Annex B: sampling result. PAK (red marker) above limit



GBA Gesellschaft für Bioanalytik mbH · Bruchstr. 5c · 45883 Gelsenkirchen

Paul Kamrath Ingenieurrückbau GmbH

Hamburger Str. 97

44135 Dortmund

ISO 14001
ISO 45001
zertifiziert



Prüfbericht-Nr.: 2020P214401 / 1

Auftrags/Proben-Nr. 20204947 / 001

Probeneingang 29.04.2020

Probenehmer durch den Auftraggeber

Material Boden

Probenbez. Köln, Füllsand

Prüfbeginn / -ende 29.04.2020 - 07.05.2020

Parameter	Messwert	Einheit	Methode
Aussehen	sandig, steinig		organoleptisch 2
Farbe	braun		organoleptisch 2
Angelieferte Probenmenge	5,84	kg	
Probenvorbereitung	manuell + Backenbrecher		DIN 19747: 2009-07 ^a 2
Trockenrückstand	96,5	Masse-%	DIN ISO 11465: 1996-12 ^a 2
EOX	<1,0	mg/kg TM	DIN 38414-17: 2017-01 ^a 2
Kohlenwasserstoffe	<100	mg/kg TM	DIN EN ISO 16703: 2011-09 ^a i.V.m. LAGA KW/04: 2009-12 ^a 2
mobiler Anteil bis C22	<50	mg/kg TM	DIN EN ISO 16703: 2011-09 ^a i.V.m. LAGA KW/04: 2009-12 ^a 2
Cyanid ges.	<1,0	mg/kg TM	DIN ISO 17380: 2013-10 ^a 5
Summe BTEX	<1,0	mg/kg TM	DIN EN ISO 22155: 2016-07 ^a 2
Summe LHKW	<1,0	mg/kg TM	DIN EN ISO 22155: 2016-07 ^a 2
Naphthalin	<0,050	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Acenaphthylen	0,057	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Acenaphthen	0,059	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Fluoren	0,070	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Phenanthren	0,89	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Anthracen	0,27	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Fluoranthren	2,0	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Pyren	1,4	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Benz(a)anthracen	0,88	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Chrysen	1,1	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Benzo(b)+(k)fluoranthren	1,3	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Benzo(a)pyren	0,88	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2

Die Prüfergebnisse beziehen sich ausschließlich auf die genannten Prüfgegenstände. Es wird keine Verantwortung für die Richtigkeit der Probenahme übernommen, wenn die Proben nicht durch die GBA oder in ihrem Auftrag genommen wurden. In diesem Fall beziehen sich die Ergebnisse auf die Probe wie erhalten. Ohne schriftliche Genehmigung der GBA darf der Prüfbericht nicht auszugsweise vervielfältigt werden. Entscheidungsregeln der GBA sind in den AGBs einzusehen.

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SWIFT-BIC COBADE33XXX

Sitz der Gesellschaft:
Hamburg
Handelsregister:
Hamburg HRB 42774
USt-Id.Nr. DE 118 554 138
St.-Nr. 47/72.3/00196

Geschäftsführer:
Ralf Murzen,
Dr. Roland Bernerth,
Kai Plinke,
Dr. Dominik Obeloer





GBAGROUP
 ENVIRONMENT

Parameter	Messwert	Einheit	Methode
Dibenz(ah)anthracen	0,20	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Indeno(1,2,3-cd)pyren	0,49	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
Benzo(g,h,i)perylene	0,52	mg/kg TM	DIN ISO 18287: 2006-05^a 2
Summe PAK (EPA)	10	mg/kg TM	DIN ISO 18287: 2006-05 ^a 2
PCB 28	<0,0010	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB 52	<0,0010	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB 101	0,0035	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB 153	0,0093	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB 138	0,0083	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB 180	0,0067	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB 118	0,0014	mg/kg TM	DIN EN 15308: 2016-12 ^a 2
PCB Summe 6 Kongenere	0,028	mg/kg TM	DIN ISO 10382: 2003-05 ^a 2
PCB Summe 7 Kongenere	0,029	mg/kg TM	DIN EN 15308: 2016-12 ^a 2
Arsen	8,4	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Blei	89	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Cadmium	0,65	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Chrom ges.	17	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Kupfer	47	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Nickel	22	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Quecksilber	0,27	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Thallium	<0,30	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Zink	206	mg/kg TM	DIN EN 16171: 2017-01 ^a 5
Glührückstand (550°C)	97,4	Masse-% TM	DIN EN 15169: 2007-05 ^a 2
Glühverlust (550°C)	2,6	Masse-% TM	DIN EN 15169: 2007-05 ^a 2
TOC	0,70	Masse-% TM	DIN EN 13137: 2001-12 ^a 2
Lipophile Stoffe	0,041	Masse-% TM	LAGA KW/04: 2009-12 ^a 2
Eluat-Einwaage	104	g	DIN EN 12457-4: 2003-01 ^a 2
Eluivolumen	996	mL	DIN EN 12457-4: 2003-01 ^a 2
Filtratvolumen	990	mL	DIN EN 12457-4: 2003-01 ^a 2
pH-Wert	9,9		DIN EN ISO 10523: 2012-04 ^a 2
Leitfähigkeit	343	µS/cm	DIN EN 27888: 1993-11 ^a 2
Chlorid	4,2	mg/L	DIN EN ISO 10304-1: 2009-07 ^a 22
Sulfat	110	mg/L	DIN EN ISO 10304-1: 2009-07 ^a 22
Cyanid ges.	<0,0050	mg/L	DIN EN ISO 14403-2 (D3): 2012-10 ^a 5
Phenolindex	<0,0050	mg/L	DIN EN ISO 14402: 1999-12 ^a 5
Arsen	0,0043	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Blei	0,0015	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Cadmium	<0,00030	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Chrom ges.	0,0026	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Kupfer	0,0046	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Nickel	<0,0010	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Quecksilber	<0,00020	mg/L	DIN EN ISO 12846: 2012-08 ^a 5
Thallium	<0,0010	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Zink	<0,010	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
DOC	3,8	mg/L	DIN EN 1484: 1997-08 ^a 2



GBAGROUP
 ENVIRONMENT

Parameter	Messwert	Einheit	Methode
Cyanid I. freis. (CFA)	<0,010	mg/L	DIN EN ISO 14403-2 (D3): 2012-10 ^a 5
Fluorid	0,19	mg/L	DIN EN ISO 10304-1: 2009-07 ^a 22
Barium	0,014	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Molybdän	0,0052	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Antimon	0,0011	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Selen	<0,0020	mg/L	DIN EN ISO 17294-2: 2017-01 ^a 5
Abdampfdruckstand	228	mg/L	DIN 38409-2: 1987-03 ^a 2
Ges.-Gehalt an gel. Feststoffen	228	mg/L	DIN 38409-2: 1987-03 ^a 2
Wasserlöslicher Anteil	0,22	Masse-% TM	DIN 38409-1: 1987-01 ^a /DIN 38409-2 : 1987-03 ^a 2
Aussehen	klar		organoleptisch 2
Farbe	farblos		DIN EN ISO 7887: 2012-04 ^a 2

Die mit * gekennzeichneten Verfahren sind akkreditierte Verfahren. Die Bestimmungsgrenzen können matrixbedingt variieren.
 Untersuchungslabor: 2GBA Gelsenkirchen 5GBA Pinneberg 22GBA Herlen

Gelsenkirchen, 07.05.2020

i. A. J. Franzen

i. A. Jan-Niklas Franzen
 Projektbearbeitung

Annex C: List of waste transports

Paul Kamrath Abbruchtechnik & Entsorgung GmbH
 Hamburger Str. 97
 44135 Dortmund

Paul
Kamrath

Abbruchtechnik
und Entsorgung
GmbH

Abfuhr / Entsorgung

Seite 1 von 3

Datum	Uhrzeit	KFZ	Entsorger	Tonnage
Köln, Bischofsweg 48a, Großmark				
170101		BetonSchutt		
15.05.2020		DO-PK 1017	REMEX (Auffüllung)	19,36 to
15.05.2020		GI-AT 605	REMEX (Auffüllung)	21,60 to
14.05.2020		DO-PK 545	REMEX (Auffüllung)	25,00 to
14.05.2020		DO-PK 545	REMEX (Auffüllung)	25,00 to
12.05.2020		DO-PK 1017	REMEX	21,00 to
12.05.2020		DO-PK 545	REMEX	22,18 to
05.05.2020		GI-AT 605	REMEX	26,42 to
05.05.2020		GI-AT 605	REMEX	27,34 to
05.05.2020		GI-AT 605	REMEX	25,22 to
04.05.2020		ME-AM 1086	REMEX	25,14 to
04.05.2020		ME-AM 1086	REMEX	29,38 to
04.05.2020		ME-AM 1086	REMEX	29,90 to
04.05.2020		ME-AM 1086	REMEX	27,58 to
04.05.2020		GI-AT 605	REMEX	26,20 to
04.05.2020		GI-AT 605	REMEX	24,52 to
04.05.2020		GI-AT 605	REMEX	23,48 to
04.05.2020		GI-AT 605	REMEX	27,42 to
04.05.2020		GI-AT 605	REMEX	25,00 to
04.05.2020		ME-AM 1086	REMEX	24,40 to
28.04.2020		DO-PK 1017	Remex	25,00 to
28.04.2020		DO-PK 1017	Remex	25,00 to
Summe				526,14 to
170107		Schuttgemisch		
24.04.2020		DO-PK 1017	RRR	21,32 to
Summe				21,32 to
170405		Metalle, Eisen		
05.05.2020			Mösta	1,00 to
Summe				1,00 to

Dienstag, 19. Mai 2020

Datum	Uhrzeit	KFZ	Entsorger	Tonnage
170504		Boden & Steine		
15.05.2020		DO-PK 545	AMAND	25,30 to
15.05.2020		GI-AT 605	AMAND	30,90 to
15.05.2020		GI-AT 605	AMAND	29,05 to
15.05.2020		ME-AM 1086	AMAND	25,90 to
15.05.2020		DO-PK 1017	AMAND	23,65 to
15.05.2020		ME-AM 1086	AMAND	30,35 to
14.05.2020		GI-AT 605	AMAND	26,90 to
14.05.2020		GI-AT 605	AMAND	26,25 to
14.05.2020		ME-AM 1086	AMAND	32,15 to
14.05.2020		GI-AT 605	AMAND	29,20 to
14.05.2020		ME-AM 1086	AMAND	25,85 to
14.05.2020		ME-AM 1086	AMAND	25,85 to
14.05.2020		DO-PK 545	AMAND	24,70 to
12.05.2020		DO-PK 545	REMINERAL	29,34 to
12.05.2020		DO-PK 1017	REMINERAL	28,90 to
12.05.2020		DO-PK 545	REMINERAL	29,02 to
12.05.2020		DO-PK 1017	REMINERAL	30,46 to
07.05.2020		DO-PK 1017	Remineral	27,96 to
07.05.2020		HA-VB 3001	REMINERAL	25,62 to
07.05.2020		HA-VB 3001	REMINERAL	26,42 to
07.05.2020		DO-PK 1017	Remineral	26,88 to
07.05.2020		DO-PK 545	Remineral	29,94 to
07.05.2020		DO-PK 545	Remineral	29,70 to
06.05.2020		HA-VB 3002	REMINERAL	27,28 to
06.05.2020		HA-VB 3001	REMINERAL	29,18 to
06.05.2020		HA-VB 3002	REMINERAL	28,32 to
06.05.2020		HA-VB 3001	REMINERAL	27,64 to
06.05.2020		DO-PK 545	REMINERAL	28,96 to
06.05.2020		DO-PK 1017	remineral	32,82 to
06.05.2020		DO-PK 1017	REMINERAL	30,54 to
05.05.2020		ME-AM 1086	REMEX	30,06 to
Summe				875,09 to

170904		Mischabfälle		
15.05.2020		DO-PK 1974	AVG	2,10 to
05.05.2020		DO-PK 1974	AVG	10,33 to
30.04.2020		DO-PK 1974	AVG	4,75 to
28.04.2020		DO-PK 765	AVG	9,70 to
24.04.2020		DO-PK 1974	AVG	6,89 to
23.04.2020		DO-PK 1974	GWA	,88 to

Datum	Uhrzeit	KFZ	Entsorger	Tonnage
21.04.2020		DO-PK 1974	GWA	,58 to
20.04.2020		DO-PK 765	GWA	,54 to
20.04.2020		DO-PK 765	eco	1,76 to
Summe				37,53 to
Sand				
15.05.2020		DO-PK 545	REMEX	26,02 to
15.05.2020		GI-AT 605	REMEX	18,28 to
14.05.2020		GI-AT 605	REMEX	26,82 to
14.05.2020		ME-AM 1086	REMEX	25,46 to
14.05.2020		DO-PK 545	REMEX	26,58 to
Summe				123,16 to
170101 Stahlbeton				
27.04.2020		DO-PK 1017	Remitec	22,72 to
Summe				22,72 to
170405 Mischschrott				
05.05.2020		DO-PK 1974	Steil	4,00 to
Summe				4,00 to
170405 Schrott				
23.04.2020		DO-PK 1974	Steil	4,12 to
21.04.2020		DO-PK 1974	Steil	2,78 to
Summe				6,90 to
Gesamtsumme				1617,86 to

Annex D: Example of pre-deconstruction audit report

A General information

A1 Description of the building		
A1.1 Building description	Single-storey steel steel hall with welded-steel frames, fabricated by unknown sandwich panel wall envelope, unknown fabricator trapezoidal sheet roof, unknown fabricator	
A1.2 Address, site number	50969 Cologne, Bischofsweg 48a, Germany	
A1.3 Year of steelwork fabrication	2002	
A1.4 Floor area	523m ²	
A1.5 Main dimensions	span: 22,26m, length 23,60 m, height: ca. 8,5m	
A1.6 Envelope	sandwich panels: 578m ² , trapezoidal sheets: 530m ²	
A1.7 Crane (description, type, tonnage)	no	
A1.8 Steelwork is already deconstructed	no	
A2 Purpose of the deconstruction		
The rental agreement for the land on which the hall is located expires. The tenant must deconstruct the hall he has built himself.		
A3 Description of the future use of deconstructed components (if known)		
n/a		
A4 Building owner (name, address, e-mail, phone)		
Fruchtimport vanWylick.GmbH, Industriestraße 16, 50735 Cologne		
A5 Information about the auditor (name, address, e-mail, phone, certification(s))		
Paul Kamrath Ingenieurrückbau GmbH, Hamburger Str. 97, 44135 Dortmund		
A6 Information about the demolition/deconstruction company (if known)		
Paul Kamrath Ingenieurrückbau GmbH, Hamburger Str. 97, 44135 Dortmund		
A7 Building documentation and drawings		
A7.1 Design documentation	no	
A7.2 Fabrication documentation	no	
A7.3 Documentation of use and inspection reports	no	
A8 Certification		
A8.1 Mill certificates of delivered steel	no	
A8.2 CE marking of delivered steel products or steelwork	no	
A8.3 Other certification:	no	

B Description of the audit and recommendations

B1 Description of the available documentation

No design documents or certificates are available. Information of past WW2 bombing is given

B2 Description of the on-site visits (dates, persons, equipment)

1st visit:

Date January 2020

Persons: Paul Kamrath, Richard Stork, Responsible owner

Equipment: Standard measuring equipment, camera

Distances, spans and cross-sections were measured during the visit. Since no design documentation was available, some of the primary structure and secondary structure was checked in more detail. Photo documentation was obtained. Connection of main frame to ground was checked in detail. The frame structure ends underneath the concrete and is not visible.

After a visual inspection, it was concluded that the structure is not visibly damaged and its dimensions are within the acceptable tolerances.

2nd visit:

Date 4 March 2020

Persons: Paul Kamrath, Markus Kuhnhenne, Kevin Janczyk, Richard Stork

Equipment: Standard measuring equipment, cameras, drones

- Site inspection
- Discussion between RWTH and PKIR concerning dismantling and testing of envelope
- Drone flights, data recording for 3D-Model

B3 Description of the labelling system of reusable components

The main structure consists of four mainframes A to D.

B4 Description of the on-site measurements (equipment, results)

Distances and cross-sections were measured by help of 3D model:

Spans: Outer: 2 x 11,13m Distance between frames: 5,3m

No regular steel girders. Connections of mainframe and secondary structure are screwed.

B5 Description of sampling (methods, sample sizes, locations, numbers)

Samples of cladding were extracted

Samples of sand were taken for the contamination tests

B6 Evaluation tools and methods for off-site testing and condition evaluation

Samples of cladding were sent to RWTH for further investigation
 Results of sand testing are included in the Annex B

B7 Results of the evaluation

Structural frames A to D can be reused as they fulfil the admissibility conditions.
 Secondary structure was not evaluated before the deconstruction.

B8 Recommended reuse scenario(s) with optional evaluation of reusability (if not in A3).

Envelope will be recycled. Insulation is used for thermal energy. Only main structure and secondary structure are reused.

B9 Recommended treatment of materials and components

Roof skin:	waste for energy plant:	AVV 17 09 04
Roof insulation:	waste for energy plant:	AVV 17 09 04
Cladding:	recycling of metal sheets:	AVV 17 04 05
Insulation:		AVV 17 09 04
Trapezoidal sheets:	recycling of metal sheets:	AVV 17 04 05
Doors, gates:	recycling of aluminium:	AVV 17 04 02
Illuminants:	recycling ba lightcycle:	AVV 16 02 14
Concrete founding:	demolition and recycling	
Off-site		AVV 17 01 01
Filling beneath:	recycling off site	AVV 17 05 04
Frame structure:	Deconstruction and reuse	

Deconstructed elements for reuse will be transported to their new place.

C Inventory of reusable components

C1 General information

C1.1 Component	C1.2 Dimensions	C1.3 Quantity	C1.4 Location	C1.5 Year of fabrication	C1.6 Will be reused	C1.7 Reuse description
Frames	see the drawings	4	see the drawings	2002	no ¹	-
Secondary structure		m	see the drawings	2002	no ¹	-
Trapezoidal Sheets		m ²	roof	2002	no	-
Sandwich Panels	see the drawings	m ²	walls	2002	no	-

¹ It was decided about reuse after the audit was completed

C2 Material information

C2.1 Component	C2.2 Steel manufacturer	C2.3 Component manufacturer	C2.4 Certified steel grade	C2.5 Recommended steel grade	C2.6 Recommended material testing
Frames	unknown	unknown	n/a	S235 without testing	-
Trapezoidal Sheet	Unknown	tba	n/a	S235 without testing	-
Sandwich Panels	unknown	tba	n/a	-	PROGRESS procedure, testing according to EN 14509

C3 Recommended treatment

C3.1 Component	C3.2 Observed damage	C3.3 Recommended repairs	C3.4 Existing coating	C3.5 Recommended surface treatment
Frames with intumescent paint	n/a	n/a	n/a	-
Purlins	n/a	n/a	n/a	-

D Inventory of waste and hazardous substances

D1 Hazardous substances

D1.1 Substance	D1.2 Present	D1.3 Quantity/concentration	D1.4 Location	D1.5 Recommended treatment
Asbestos	no	n/a	n/a	n/a
PCB	no	n/a	n/a	n/a
Creosote	no	n/a	n/a	n/a
Other: no		n/a	n/a	n/a

D2 Inventory of waste¹⁹

D2.1 Material	D2.2 Code	D2.3 Hazardous	D2.3 Quantity	D2.4 Location	D2.5 Condition	D2.6 Recommended treatment
Iron and steel	170405	no	30 t	steelwork	painted, corroded	R4 (recycling of metals)
Concrete	170101	no	500 t	base slab	good for recycling	R5 (recycling of inorganic materials)
Mixed CDW	170703	no	60 t	base slab	n/a	D12 (permanent storage/backfilling)
Soil and stones	170504	no	800 t	excavation	n/a	D2 (land treatment)

E Drawings and photos





