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Example of a conservation plan: Garden City 'Elmschenhagen-Nord', Kiel

Figure 1: Row house, 'Kiel Elmschenhagen-Nord'

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1 Origin and history of the project

Origin of the project ‘Energetische Modernisierung der Gartenstadt Elmschenhagen-Nord’ is the Climate protection activities of the City of Kiel. The climatic protection concept of the city, set up in 2008, recognises the potential to reduce CO_2 emissions to 54% by the year 2020, a.o. through the reduction of primary energy consumption and an increase in the share of regenerative generated energy (electricity and heat). The results of the Innovative Building Exposition (InBA) in Kiel in 2008 had a special role in this. The InBA was the German contribution to the EU Project REBECEE (Renewable Energy and Building Exhibition in Cities of the Enlarged Europe), which included a series of innovative and ecological building exhibitions in Middle and Eastern Europe. Within the concept of the InBA, passive-house standards were favoured, especially for new buildings. Subsequently these energy standards became part of the energy and climate-protection concept of 2008 as mandatory principle for town planning and for building and redevelopment measures, e.g. in civil planning and city building contracts. With the mandatory saving-standards set, the question was naturally posed, how the outer walls could be insulated by simultaneously preserving the brick façades, which are characteristic for the cityscape of Kiel. Henceforth an approach is now pursed, at which town planning and political energy goal setting is steered through an integrated process of governmental standards as well as intensive information-sharing, co-operation and consultation by all involved parties. In the garden-city ‘Elmschenhagen-Nord’ this process has been implemented as a pilot project for a number of years.

2 The Garten City ‚Elmschenhagen-Nord‘ *)

The settlement situated north of the B76 direction Lübeck/Plön is about 39 acres large. The ensemble is not heritage protected, but it falls under the ‘North German homeland design protection’ due to the use of bricks as typical regional building material. In the app. 130 two-storey townhouse lines with app. 1,800 units live app. up to 4,000 people. The consistent structure of the habitation area is characterised by the two storey townhouses in red-brick with joint and similar fashioned front gardens. Garden spaces are situated behind the town houses, interrupted by leafy footpaths as extra connection to the service roads. In the middle of the area, around the ‘Andreas-Hofer-Platz’, there are two storey habitation and commercial complexes, built as special types but out of the same building materials. The buildings are divided by advancing fissures in the building line, a scaling of gables or special corner solutions. Furthermore there are stepped gables, archways at gangways and pergola designed elements as artistic elements of the house rows.

Figure 2: Binding land-use plan no. 974 'Kiel Elmschenhagen-Nord'

The development of the area commenced in March 1939 by the Hamburger Settlement building society 'Herman and Paul Frank' for the navy. The architects Frank had already made experience with garden-city-settlements. Their garden-city-settlement in Hamburg Klein Borstel (1935-39) served the 'Nationalsozialisten' as exemplary settlement. In the 2nd WW huge areas of the garden-city-settlement 'Elmschenhagen-Nord' were destroyed, and reconstruction continued up to the mid 1950's.

3 Modernisation approach

Due to the fact that the area does not fall under heritage protection it was decided to make appropriate regulations in the land development plan in order to maintain the quarter. The building-plan No 974 therefore contains specific requirements to preserve the stock, e.g.:

- Brick-red exposed brickwork
- Defined roof pitch for the main buildings
- Colour of the roof covering
- Consistent ridge and eave-lines

The building-plan is supplemented through a conservation statute, which prescribes further authorisation requirements for building measures and exceeding those of the state building code. To motivate homeowners in the area to comply with high energy standards, a special consultation and grant offer has been conceived. An essential component hereof was the development of a model reconstruction concept in advance. On this basis a fast and efficient support concerning the energy saving measures carried out by the owners could take place, ensuring as well the adherence of the design requirements.

4 Development of a model reconstruction concept *)

Within the development of the model reconstruction concept it was necessary to check if the InBA-standards, meaning at least the new building standard according to EnEv 2007, could be in principle implemented in residential areas with specific demands regarding heritage worthy design. Therefor the use of renewable energies became vital for the garden-city. For example the heat supply should preferably consist of 100% regenerative energy. According to these specifications the previously set targets can be reached with the reconstruction models described below. Also model details were developed which fulfil the requirements of an up to date heat insulation with simultaneous consideration of the building-plan regulations.

4.1 The building types *)

The row-houses of the settlement are essentially composed out of the following fundamental types. The gable, resp. townhouse type 296 with two apartments and a mildly protruding oriel, represents the distinctive end type of a house row. It has an axle width of app. 5.575 m and a building depth of 8.12 m. This house row is completed with the townhouse type 60 comprising one apartment on a foundation of 4.22 m by 8.12 m. Whereas the Type 92, as middle or end house, has a building depth of 8.65 m. Beyond that special types with shops or access balconies are to be found in the centre of the town.

Figure 3: Row house type 296 and type 60, 'Kiel Elmschenhagen-Nord'

Due to its frequency the middle-house type 60 was chosen as basis for the model reconstruction concept. For this house various examples for heating and insulation were conceptualized in detail and also calculated in different variations. With this method insulation measures were developed for all parts of the building shell. Subsequently several possibilities of heating systems were reviewed. In the next step the thermal and technical characteristics of a compiled house row, comprising out of eight middle-houses type 60 and two gable types 296, was examined.

4.2 The building structure and its particularities *)

The residential buildings in the settlements are constructed in red brick and built with base, ground and upper floor. For this purpose they are bricked up on a substructure of concrete well rings which are connected with segmental arches on which the primary structures of the cellar outside- , middle– and building partition walls rest. The cellar outside-wall is sturdy with a thickness of 34 cm and the building's base slab is made out of concrete with a thickness of app. 10 cm. Since the cellar only has a head room of 1.96 m a subsequent insulation of the base slab is complicated. One cellar-room was erected as an air raid precaution-room with exceptionally sturdy walls. Originally it was planned for a use with a toilet and a bathtub, for which there are cables underneath the base slab. The outer walls of the ground and upper floors are constructed as a double wall, on the outside an 11 cm clinker, on the inside an 11 cm sandy limestone and an app. 6 cm wide air gap in between. All windows and doors possess an inner latch. The ceilings are made out of concrete and rest on the outer brick structure. The ceiling between ground and upper floor is connected with a massive joist to the outer wall and therefore interrupts the air gap. At this point a wooden-wool lightweight slab is placed on the inner side of the outer wall. This was designed as a lost casing and with a thermal buffer effect against condensation.

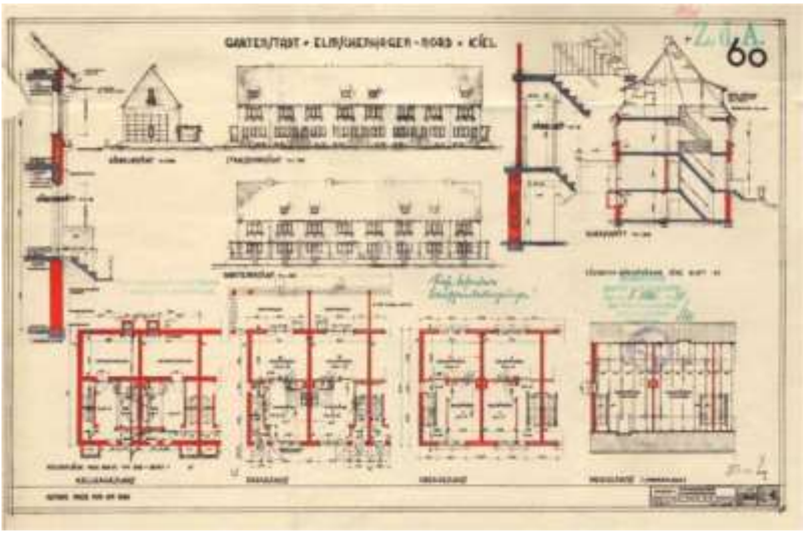

Figure 4: Row house type 60, 'Kiel Elmschenhagen-Nord'

The Purlin roof is erected from coniferous wood with rafters of about 8 x 12 cm and a pitch of app. 50 degrees. The existing small dormers show that this attic was original planned as an expansive reserve. On basis of the old existing plans from the year 1939 it was assumed for the model reconstruction concept that the two storey townhouse types share the same design. Restoration or reconstruction works in later years could partly have caused different constructions which were, however, neglected in the survey.

4.3 The energy standard-deficiencies *)

The buildings were erected quite sparingly, with simple structural constructions e.g. small wooden beams without any interior cover. The wooden framed windows were single glassed and therefore the weakest thermal point in the outer shell. Furthermore all salient components, for example the oriel, gable, flowerpot holders, outside stairs and so forth, were directly connected to the construction of the outer shell.

Because of the refurbishment work which has been done previously on most of the houses, comprising central heating systems and isolating synthetic windows, some structural physics conditions have been changed. Another problem was that for a renovation according to actual standards the building shell had to be energetically optimized and the thermal bridges and air leaks had to be eliminated. These steps would once again change the structural physics of the building components. Inappropriate modernisation could for example cause condensation on the thermal bridges. Furthermore it is also possible that faulty ventilation could cause mould formation on cold surfaces. Due to these reasons all measures are to be carefully balanced in advance.

The measures recommended in the framework of this model reconstruction concept were developed in detail on the basis of the calculations. They have to be checked and, if necessary, adapted for each building on-site. Normally this is done by a building physicist/energy consultant and/or architect/engineer.

4.4 The energy analysis of the buildings *)

Computer aided energy analysis
On the basis of the on-site visits and available documentation a computer aided energy analysis was made. For this purpose the energy flows were determined on basis of the building's installation and technical data. These energy flows consist of the thermal losses through the building shell, especially windows, outer walls, storey-ceilings and roof surfaces, as well as ventilation losses and losses through the heating system resp. the hot water preparation. After determining the status quo in a next step the weak points were analysed and refurbishment-measures were suggested. The effectivity of the measures was judged on the energy-savings, the cost-effectiveness and the pollutant load. Thereafter further measures were suggested which were however, due to the variety and necessary efforts, not singularly valued in terms of energy-saving, cost-effectiveness and emissions.

Principally there are various approaches to make an energy diagnosis for buildings. The procedures differentiate mainly concerning the degree of details and in the consideration of the user behaviour. In this report the calculations which were executed were based on the DIN-Norms, the VDI codes and the energy saving regulation of 2009. The influences of the user behaviour were mostly disregarded in this method. This allows an evaluation of the pure structure as well as the installation system. Since nevertheless standard user behaviour is assumed it might be possible to draw conclusions about the user behaviour by comparing the calculated energy demand with the real energy use. All noticeable energy relevant circumstances and occurrences were, as far as it was possible, considered. If no evaluable data was accessible, empirical values for typical building and facility components of the respective building period were used. Therefore the stated costs and energy-savings are only approximate values and might differ from the actual conditions.

Thermography *)
Within the scope of the thermal analysis, a thermography of the building shell was made with a thermography camera. The pictures in figure 5 show the thermal conditions on the outer façade before the reconstruction (left) and after (right). For every singular pixel the thermal radiation was assigned to a temperature value with the help of an internal method of calculation of the IR- camera. This temperature range can be found in the colour palette on the right of every picture.

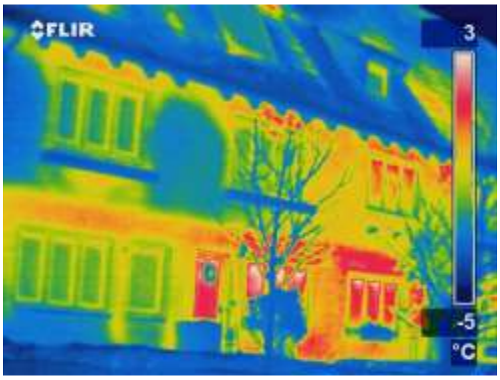

Figure 5: Thermography of the building envelope

In the refurbished building (right picture) the air duct in the outer wall was filled in with insulation; recognisable through the low temperature on the outer surface (blue). In the area of the bearing of the storey ceiling and the croppers and soffits of the windows the thermal radiation is significantly higher (yellow to red). Because these areas are compact and completed without an air duct, the thermal loss is rather significant.

Thermal bridges and air-tightness *)
Thermal bridges are areas in the outer building structure where the heat transfer is bigger than in the surrounding structural surface. The inner surface at thermal bridges cools down severely at low outer temperatures. Geometric and construction based thermal bridges cannot be completely avoided, even in well insulated buildings (e.g. outer wall ceilings). In the tested buildings especially the bearings for the flower boxes and the massive areas in the outer surface (scuncheons, croppers, ceiling structures) represented thermal bridges (see figure 5).

The air-tightness of the building shell also has a big influence on the heating requirements. An uncontrolled thermal exchange, e.g. through leaky joints and fittings, may considerably increase the energy consumption of a building. The compact structure of the tested building ensures already mostly the required air-tightness. Many roofs were already insulated in the 80's, however not in a technically correct manner. Therefore generally no separate airtight layer (foil or similar) was implemented. In the further calculations a thermal exchange rate of $n = 0.7\ h^{-1}$ is assumed. The building ventilation through the users has been found to be 'good'.

4.5 Development of modernisation variations *)

Based on the previously mentioned test results various modernisation variations were developed for which, apart from the provision of detailed structural sketches, the extents of energy savings as well as the investment costs were prognosticated in order to calculate the economic viability.

- Variation 1: Actual state
- Variation 2: Reference building ENEV 2009
- Variation 3: Cellar (insulation of outer walls and soles)
- Variation 4: Windows (replacement of windows and doors)
- Variation 5: Outer walls (core-insulation with polystyrene-granulate)
- Variation 6: Outer walls (core-insulation with nano-gel)
- Variation 7: Outer walls (thermal-insulation composite system)
- Variation 8: Ceiling (insulation of the top storey ceiling und slide-in stairs)
- Variation 9: Roof (insulation of the roof slopes with rafter reinforcements)
- Variation 10: Complete insulation + condensing gas boiler + solar thermal
- Variation 11: Complete insulation + wood-pellet heating
- Variation 12: Complete insulation + air-water heating pump

5 Executed reconstruction and further measures

The following results have already been achieved on the basis of the model reconstruction concept by May 2013:

- 103 Townhouse owners were advised
- 66 Owners have implemented energy saving measures (average investment of 2,500€ / townhouse)
- 3 apartment buildings (with 30 flats) were completely renovated by the owner 'FrankECOzwei-Group' (100,000 € / building)
- Savings in energy of 360,000 kWh / year with these measures and CO_2 economisation of 72 tons / year

The advisory service given within the model-reconstruction concept will be continued in the future and supplemented with further services, like e.g. the execution of a hydraulic adjustment for the heating system.

Further documentation about the model reconstruction for the Garden-city Elmschenhagen-Nord is available on: http://www.die-lernende-stadt.de/gruppe/quartiersprojekt-elmschenhagen-nord.

*) Source: "Energetische Modernisierung und Baudenkmalpflege am Beispiel der Gartenstadt Elmschenhagen", H-architekten: Thomas Hahn - Stefan Saleh / Energieberatung: Dipl.-Ing. Jasper Harten, Kiel, 2010/11