# Sound in lightweight structures
# - Research activities at PTB -

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# Outline

- Background
- Test site for installation noise
- Investigations on lightweight structures
- Source properties
- Conclusions and outlook

## Background

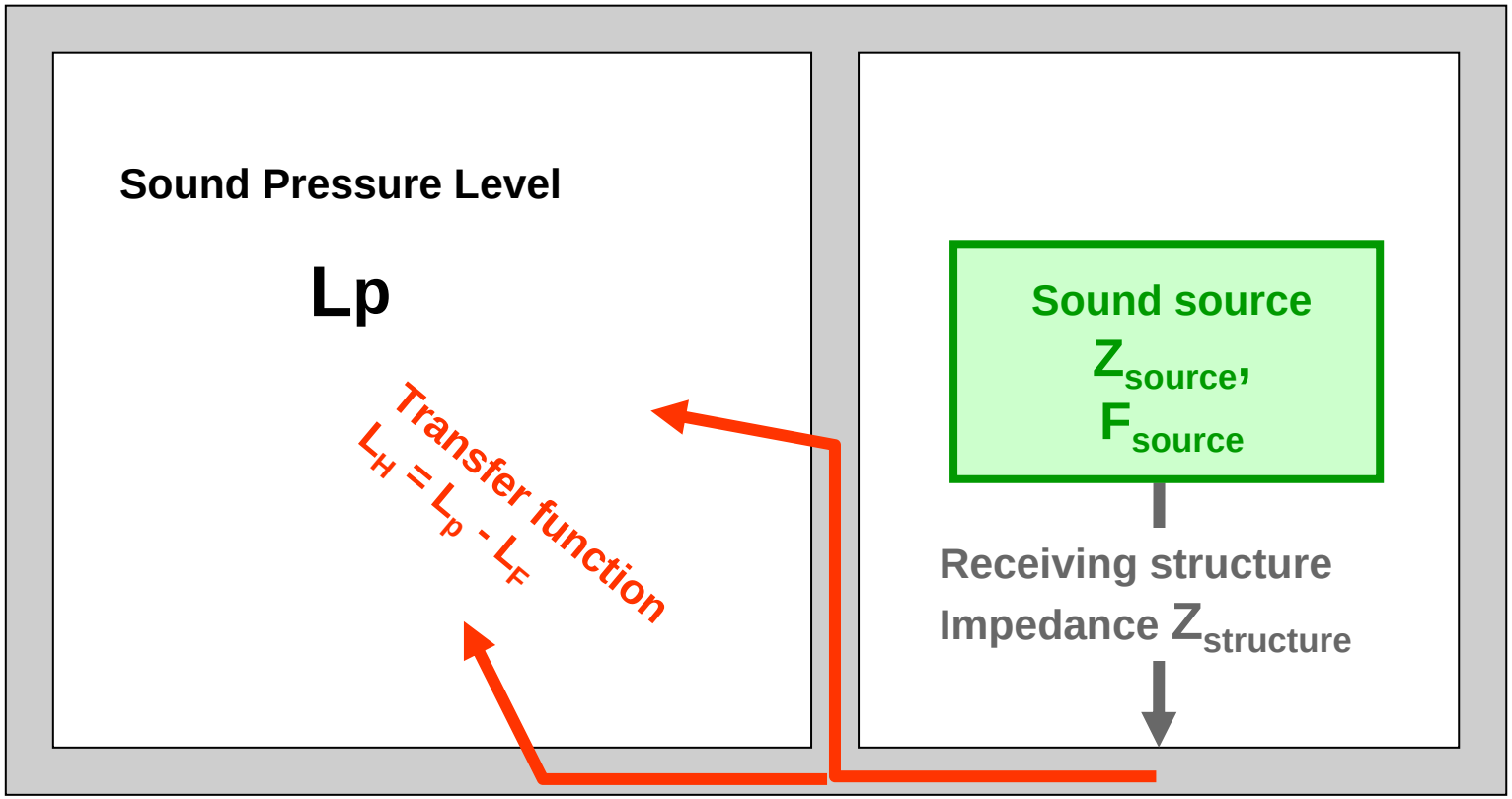
– **Increasing number of timber-frame multiple-dwelling units expected**

– **German regulations (DIN 4109) apply, but no prediction method for technical installations (solid structures not applicable)**

– **So far no laboratory procedure for technical installations in lightweight buildings**

– **Increasing concern also on sound issues in single family houses**

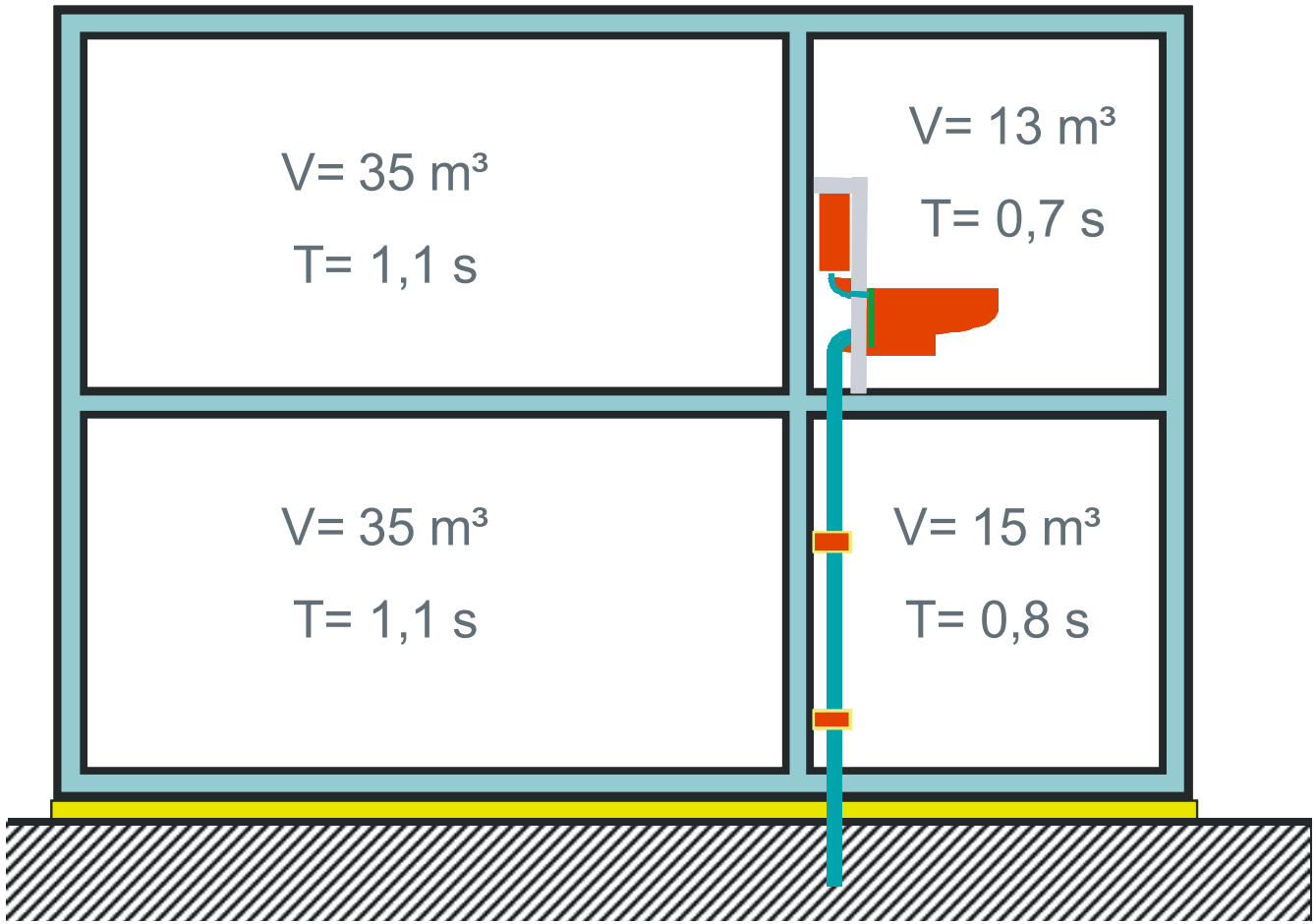
# Assumptions for a prediction




**Prediction using $k_{i,j}$ too complex (?) ➔Transfer function**

**$Z_{structure}$ >> $Z_{source}$ not fulfilled**

# Test site for installation noise




**Co-operation with the German association of prefabricated house manufacturers (BDF)**

# Test site for installation noise

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– **Installations by 11 manufacturers of houses (BDF)**

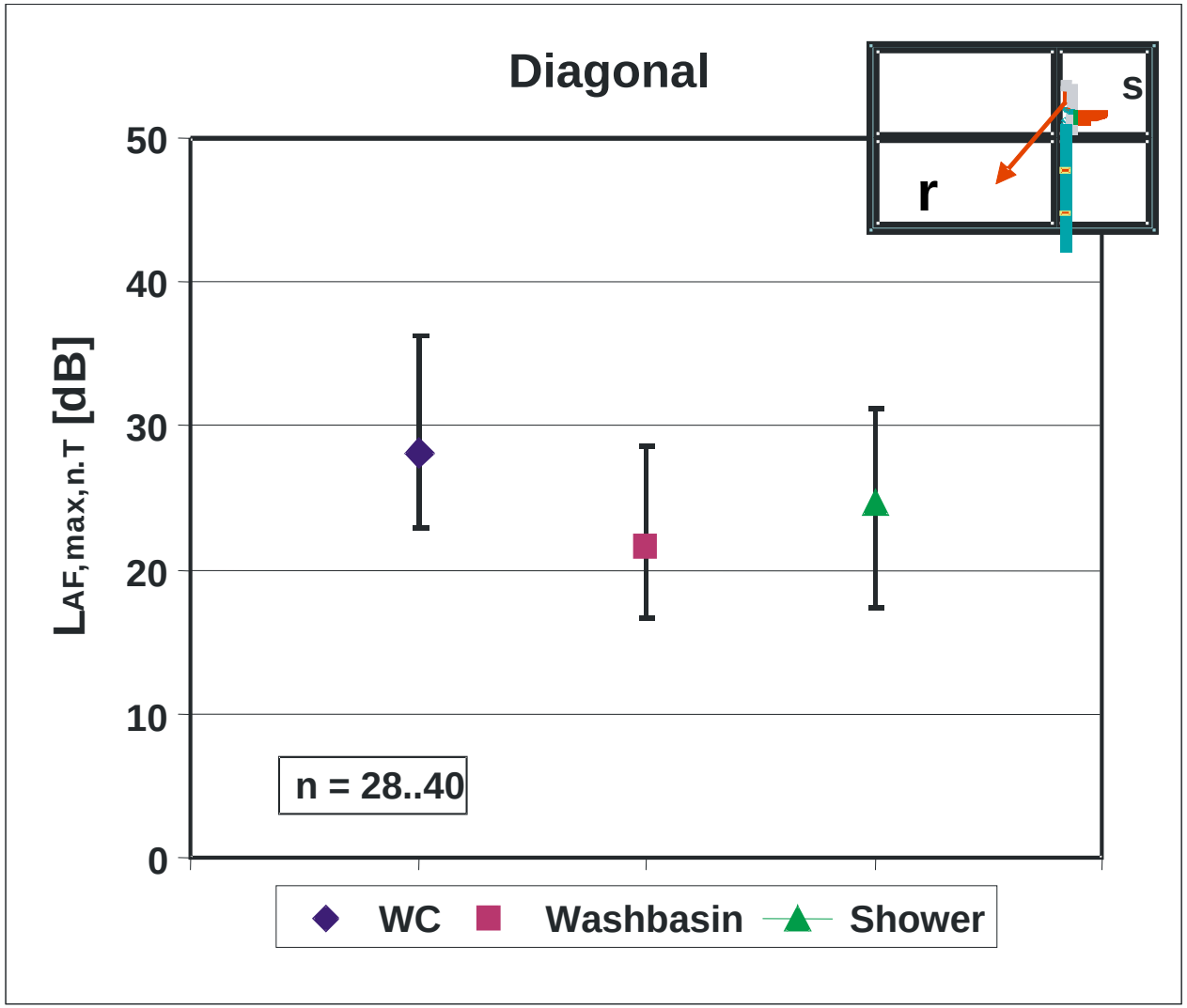
– **20 variations in total**

– **Standard configuration: Shower, washbasin, WC**

– **Measured: $L_{AF,max,n,T}$ ; $R_w$**

➔ **WC most critical sound source**

# Test site for installation noise



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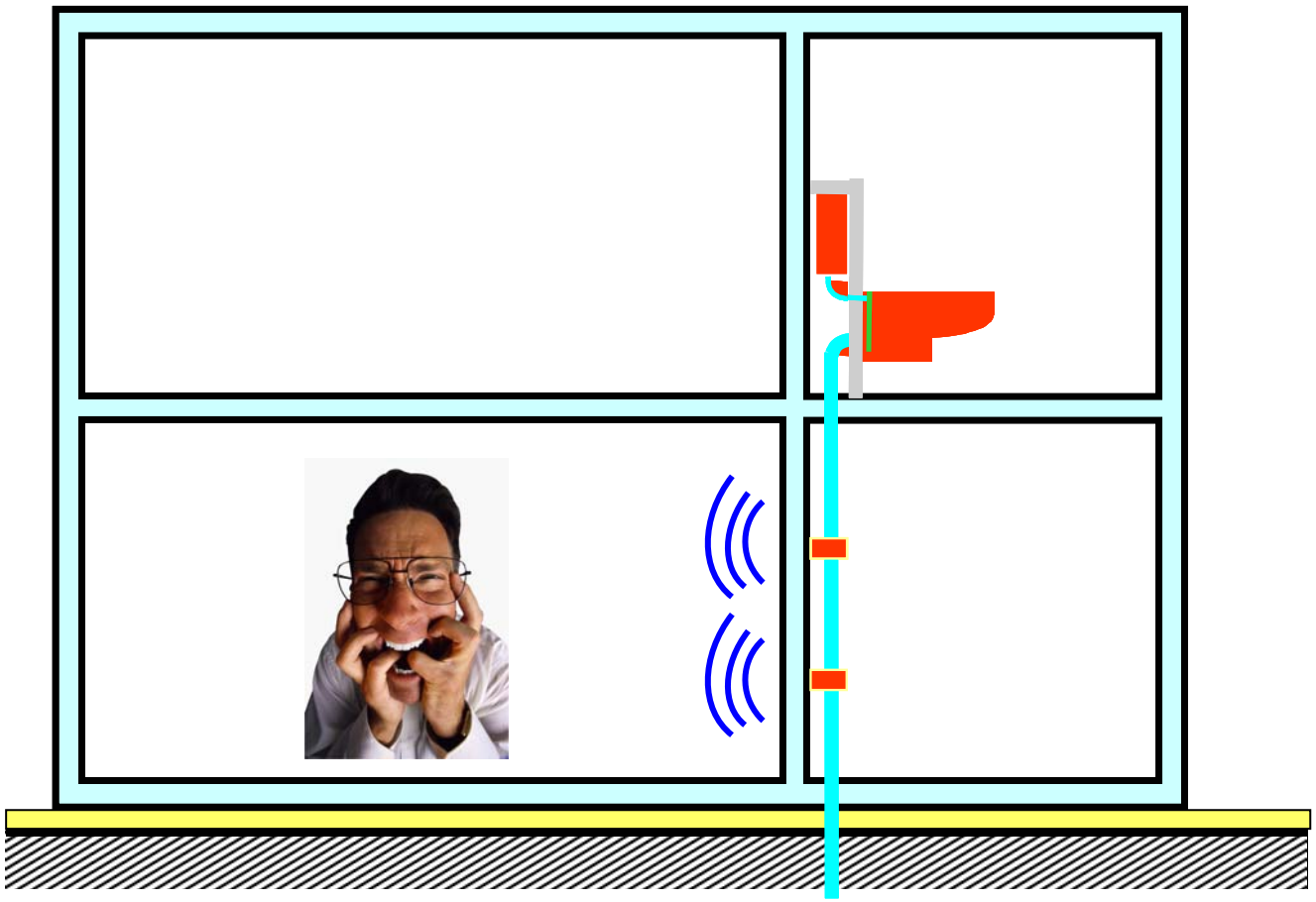


# Measurements in existing buildings

– **Measurements in 7 buildings**

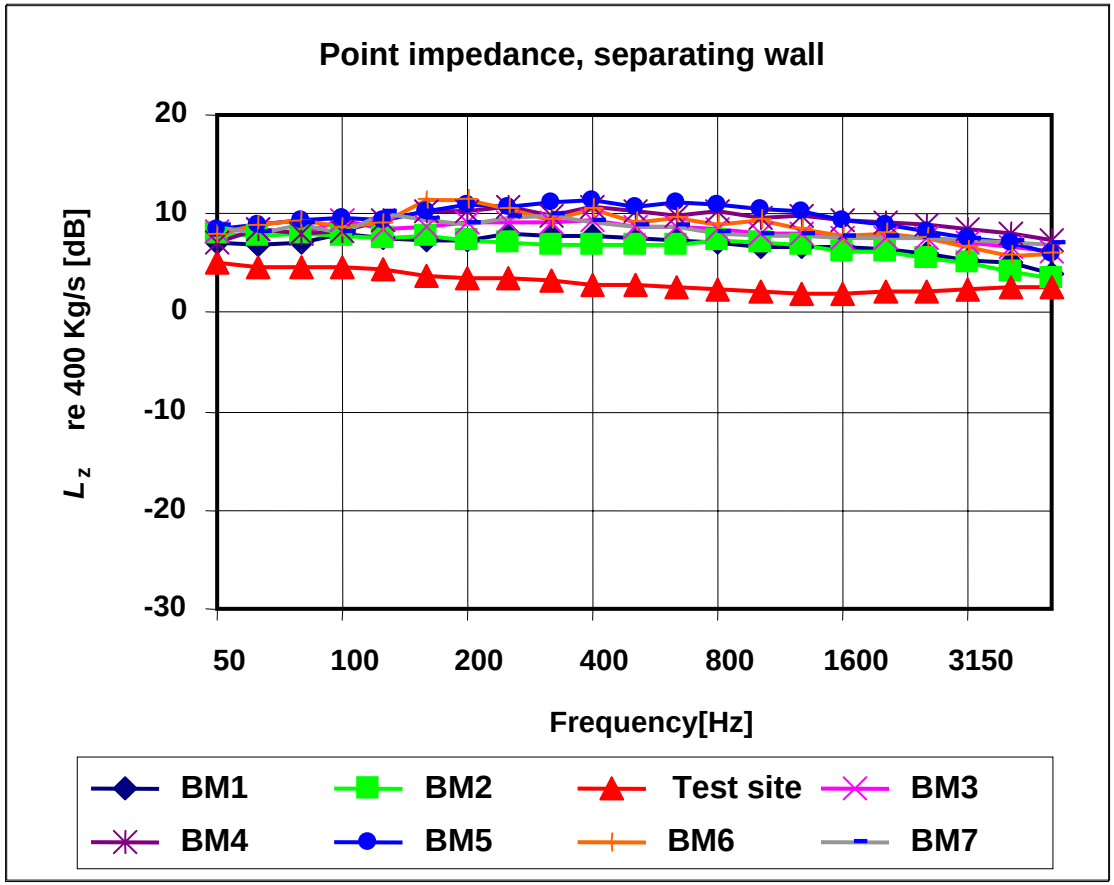
  **(6 single family, 1 multiple-dwelling)**

– **Measurement of installation noise and**

  **structure-borne sound parameters**

➔ **Installation noise often higher than at test site**
➔ **Layout of building crucial in multiple-dwelling unit**

# Measurements in existing buildings

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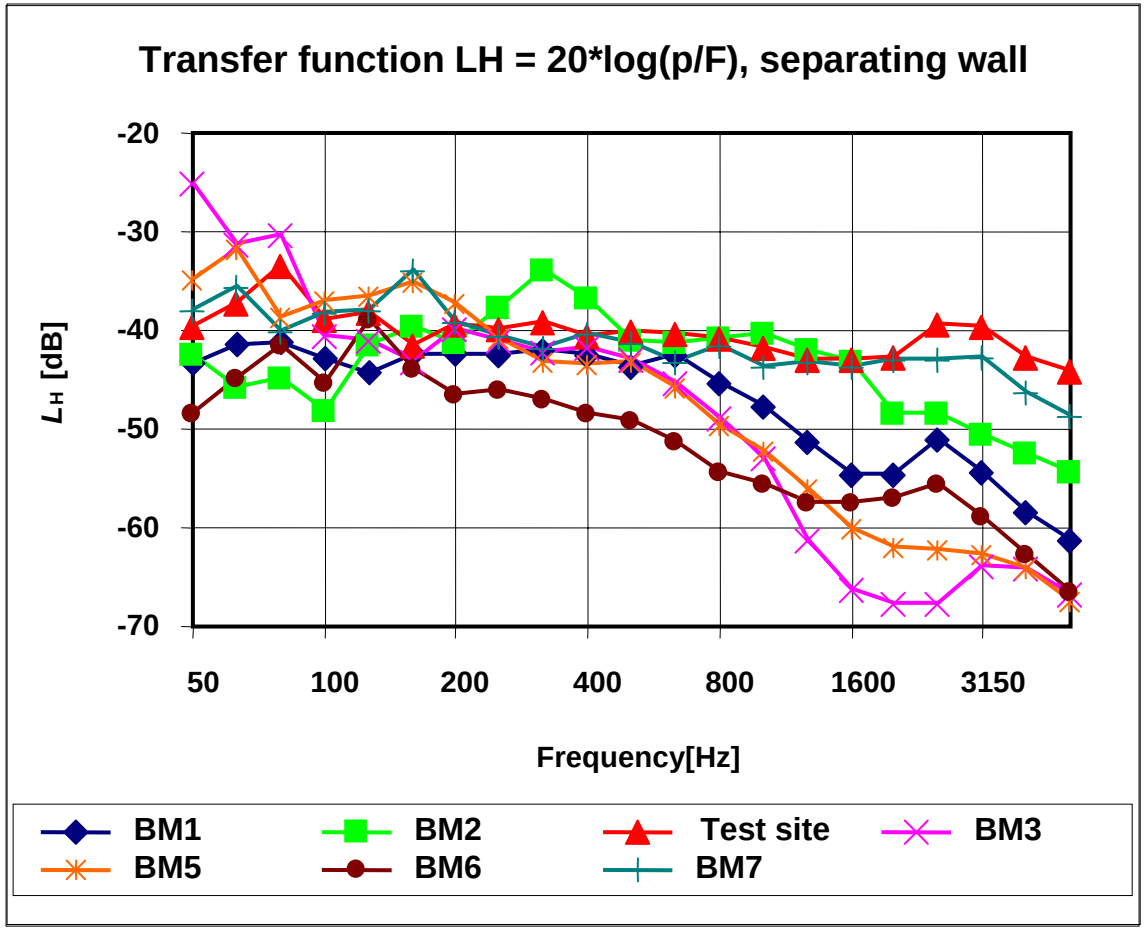
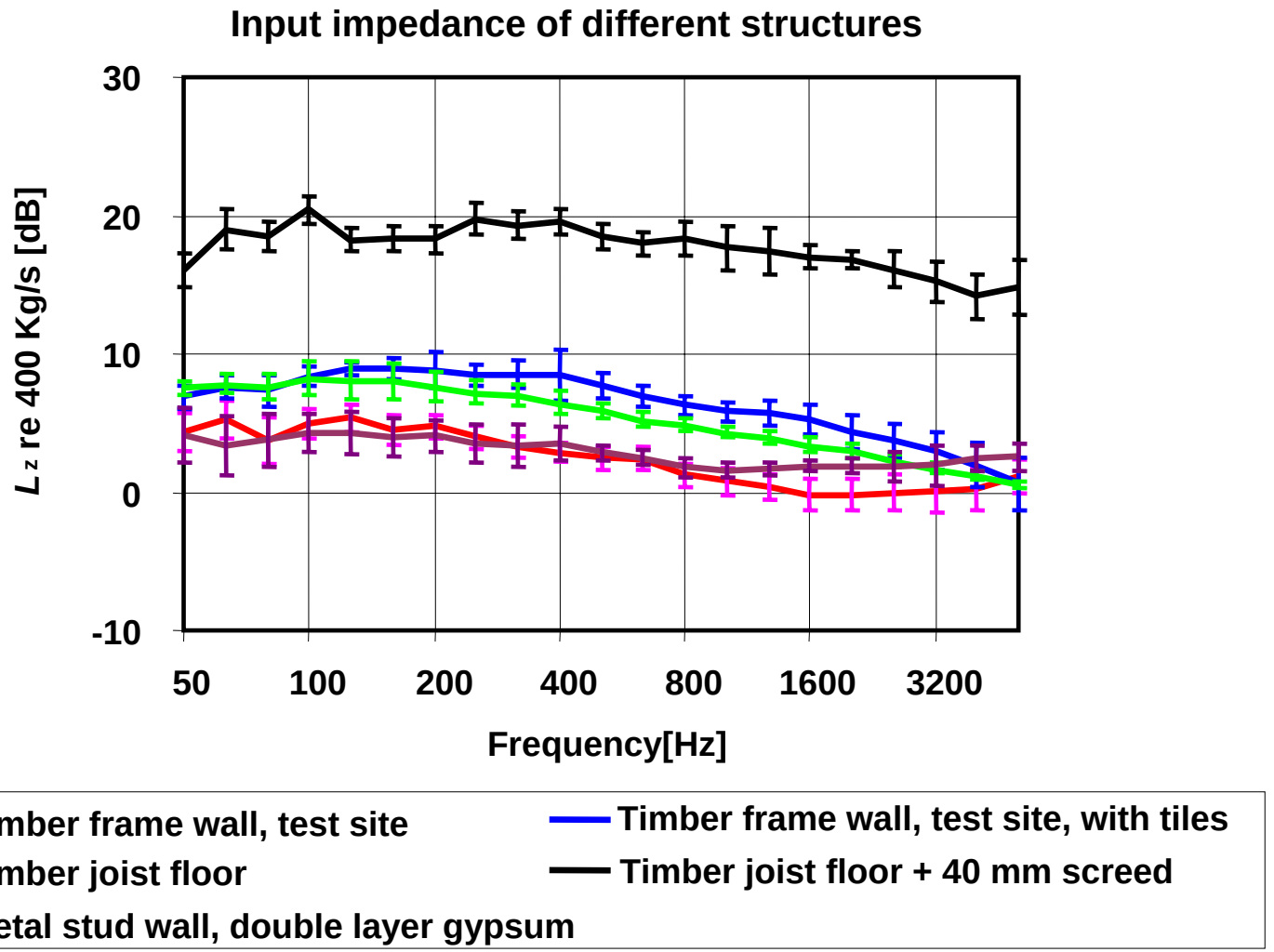


## Further investigations on lightweight structures

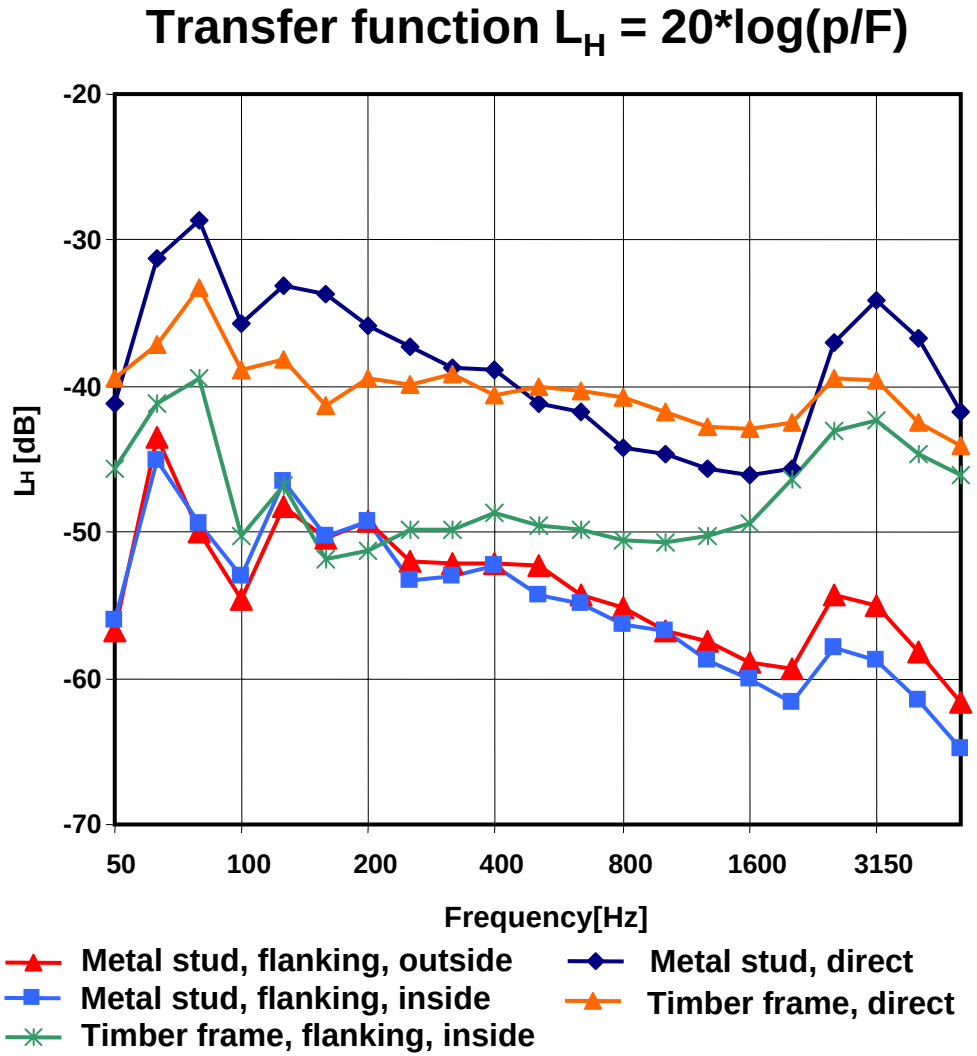
– **Input impedances**

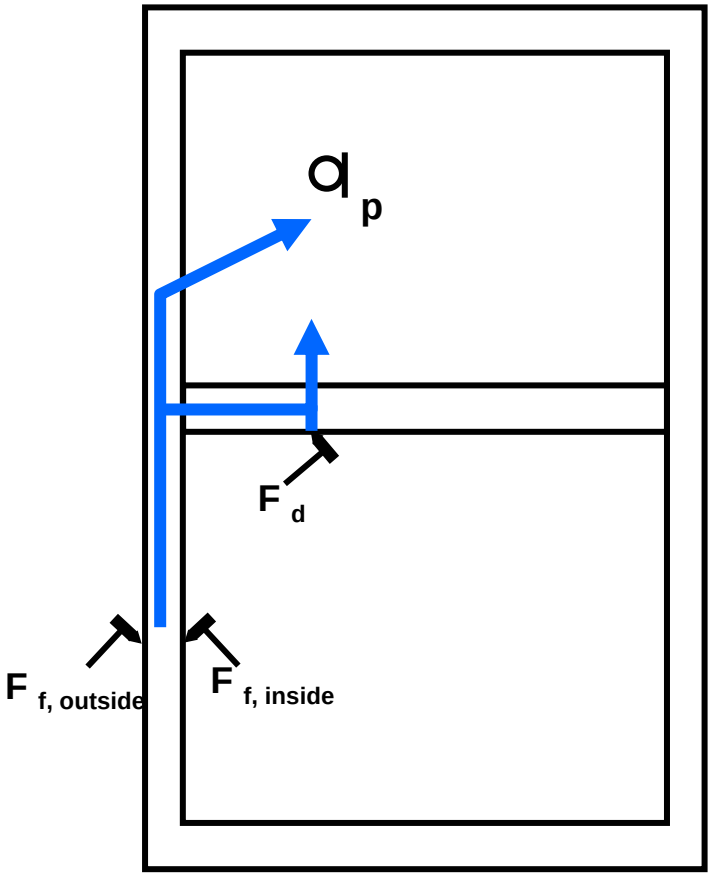
– **Transfer functions**

# Investigations on lightweight structures



# Investigations on lightweight structures



## Source properties

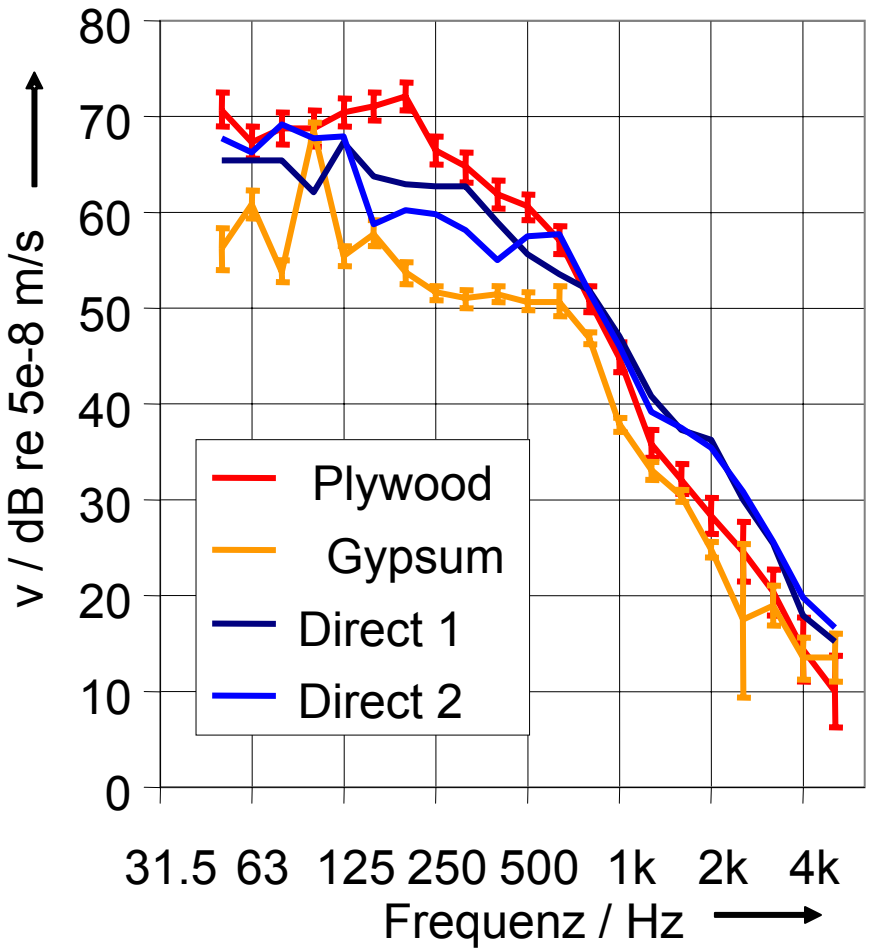
– Impedance / mobility, free velocity, blocked force

– Direct measurements and two-plate method

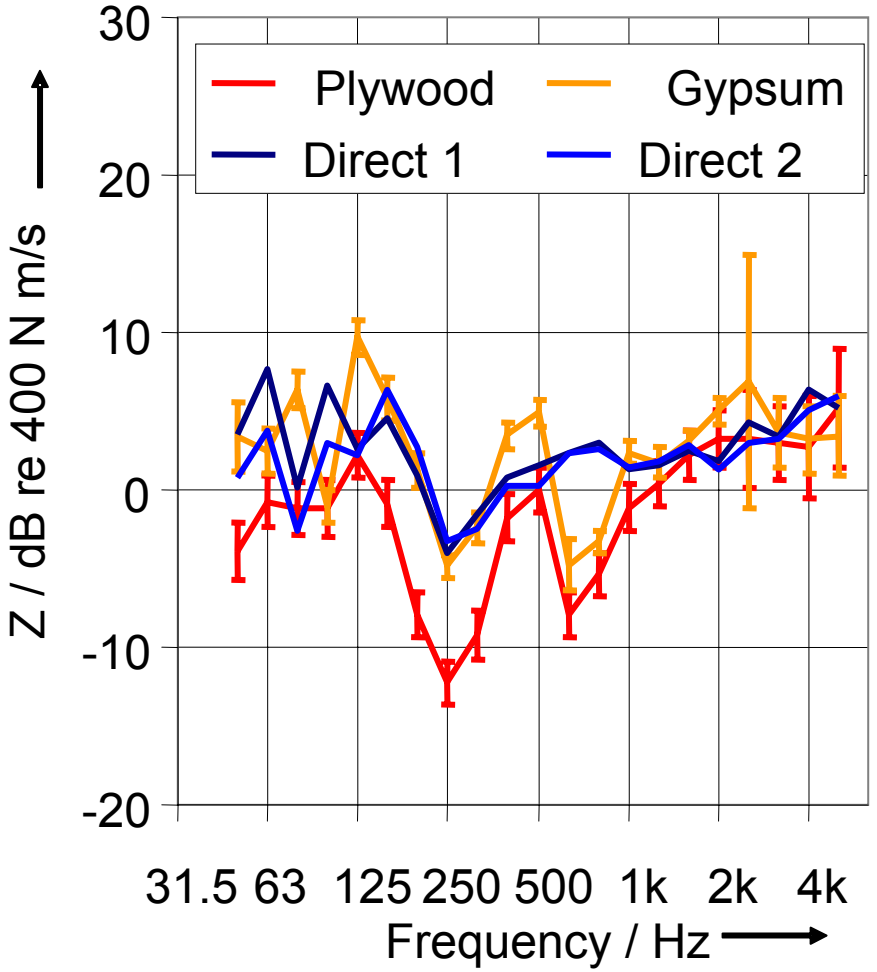
– Test objects: Waste water pipe and human walker, tapping machine (modified and unmodified), shower jet, shaker

# Source properties – Waste water pipe

## Free velocity




## Impedance



# Source properties – Waste water pipe

**Further measurements on waste water pipes:**

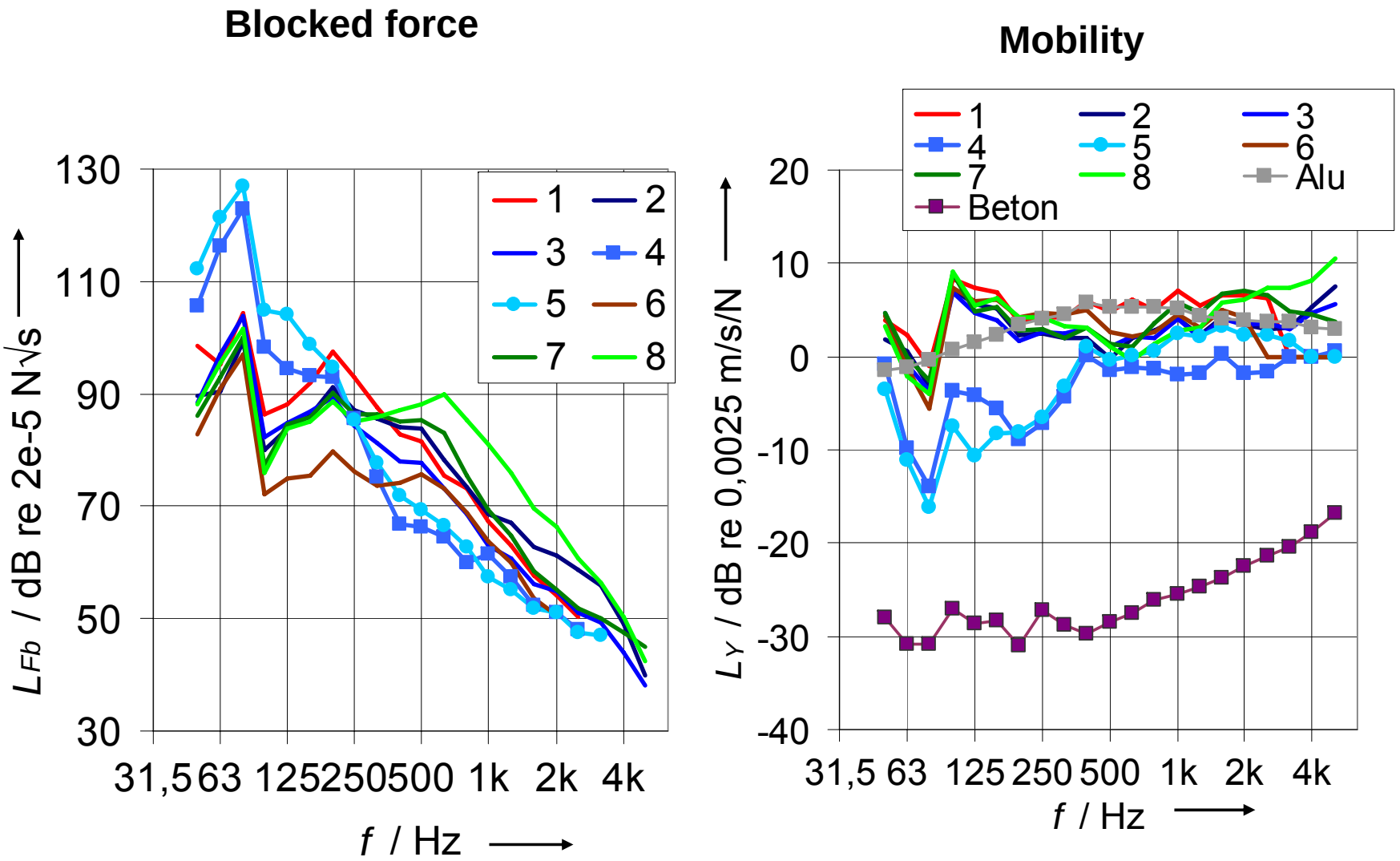
- **Direct measurement of impedance, different pipes filled with water at different levels**
- **Influence of different clamps on transmitted sound power**

➔ **Influence of filling on impedance widely negligible**
➔ **Influence of clamps generally small**

# Source properties

| Walker | *m* (kg) | Footwear, (stiffness of sole) |
|---|---|---|
| 1 | 68 | Low shoe, medium |
| 2 | 95 | Low shoe, soft |
| 3 | 95 | Safety boot, soft |
| 4 | 95 | Socks, walking |
| 5 | 95 | Socks, „Heeldrop“ |
| 6 | 40 | Winter boot, soft |
| 7 | 65 | Bootee, medium |
| 8 | 65 | Pumps, hard |

# Source properties: Human walker



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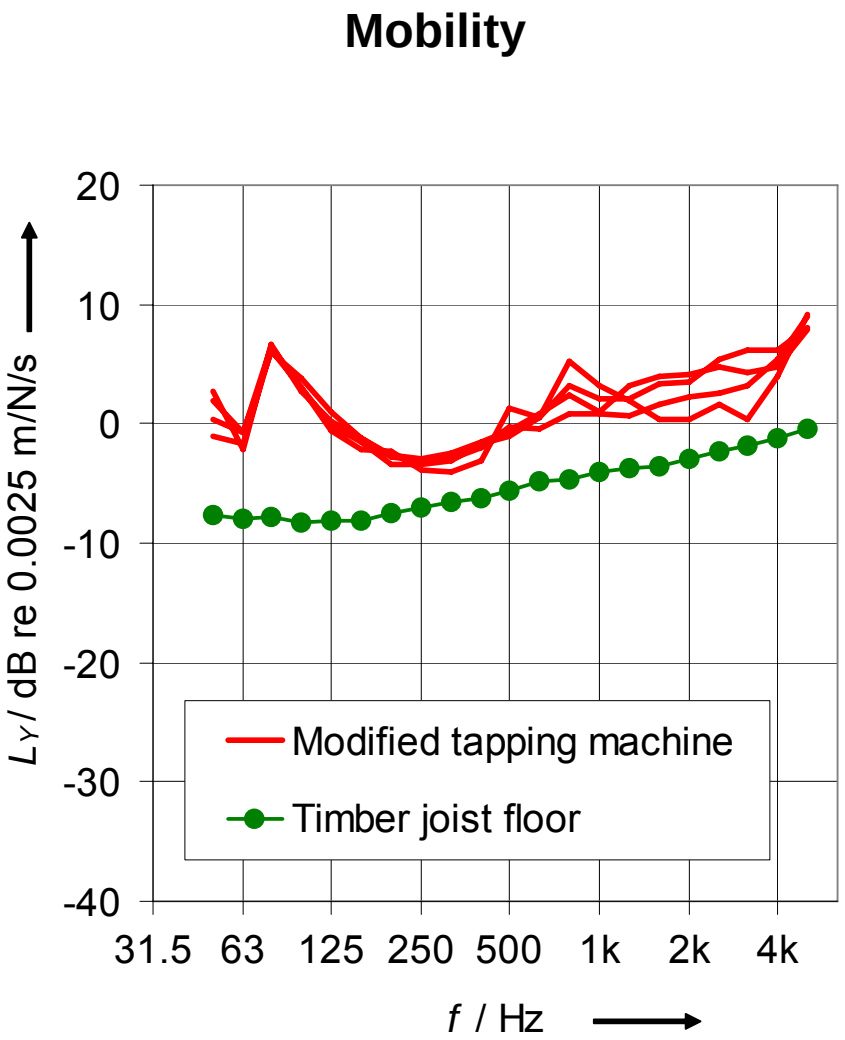


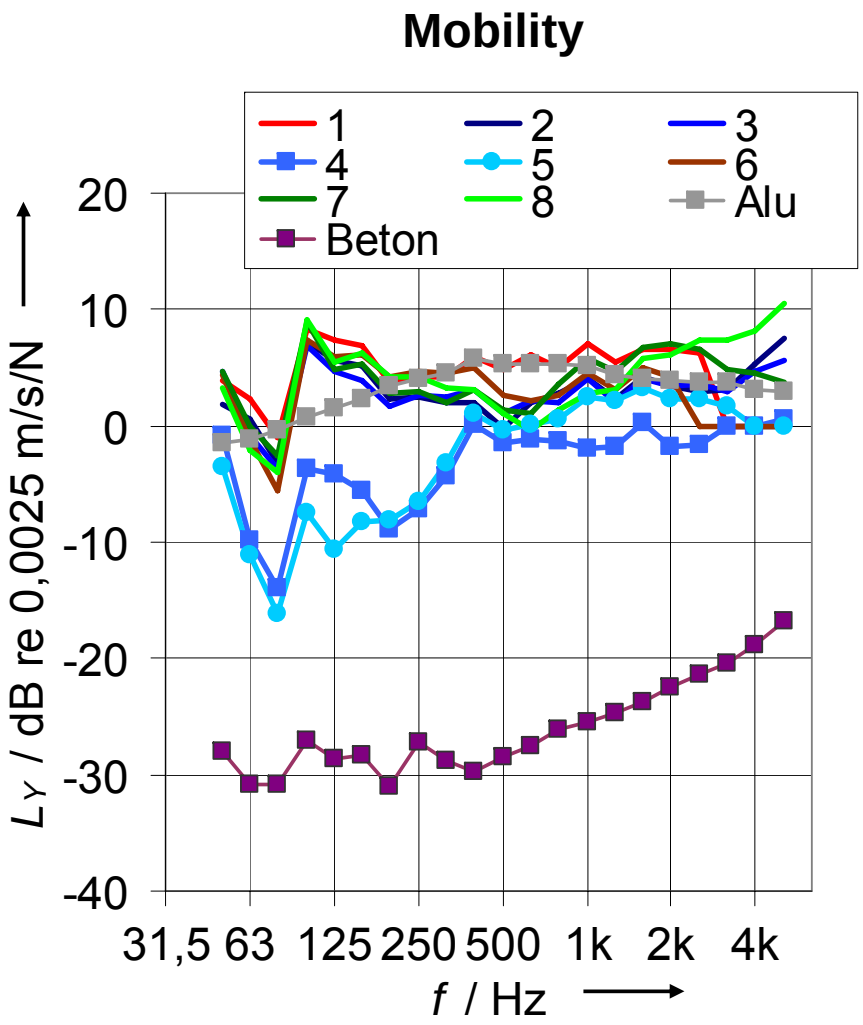

## Conclusions

- Timber-Frame houses can meet the German requirements for installation noise, if planned and constructed properly
- Waste water pipe is a major sound source (Impedance match)
- Impedances in different walls comparable, but large deviations for transfer functions
- Realistic source characterisation possible with 2-Plate-Method

## Outlook

– **Ongoing research on transfer functions necessary (PhD work in cooperation with Bauhaus University Weimar)**

– **More source characterisations**

– **Test of prediction using simple setups in first stage**