SEMINAR ON “TESTING AND CERTIFICATION OF GREEN CONSTRUCTION MATERIALS”

Sound Insulation for Glass and Panel

Ir Dr CHONG Fan
HIGHLIGHTS

1. Sound insulation of building construction
2. Sound insulation tests
3. Prediction models for sound insulation
4. Improvement of sound insulation
SOUND INSULATION OF BUILDING CONSTRUCTION

- What is sound insulation of building construction?

  - It is a measure of the ratio of the sound energy striking the building component relative to the energy which is transmitted through the building component.

  - Sound insulation / sound transmission loss (\( TL \)) is expressed in decibels as follows,
    \[
    TL = 10 \log( W_1 / W_2)
    \]

  - \( TL \) of a building component varies with frequency, usually increasing as the frequency increases.
SOUND INSULATION OF BUILDING CONSTRUCTION

- Important to know the Sound Insulation Performance of Building elements
  - To compare different constructions
  - To calculate acoustic privacy between rooms
  - To calculate noise levels from outdoor sources, such as road traffic
  - To engineer optimum solutions to noise control problems
SOUND INSULATION OF BUILDING CONSTRUCTION

- Single-number rating of airborne sound insulation
  - Sound Transmission Class (STC)
    - ASTM E90
  - Weighted sound reduction index \((R_w)\)
    - BS EN ISO 140-3
  - \(R_w\) and STC ratings are determined by laboratory test of a specimen.
  - The higher the \(R_w\) or STC rating, the better the sound insulation provided by a partition.
SOUND INSULATION TESTS

- Two adjacent reverberation rooms are arranged with an opening between them in which the test specimen is installed.
SOUND INSULATION TESTS

- Care is taken that the only significant sound transmission path between rooms is by way of the test specimen.

- An approximately diffuse sound field is produced in both rooms.

Acoustic reflectors were installed in the reverberation chambers.
SOUND INSULATION TESTS

- Sound incident on the test specimen causes it to vibrate and create a sound field in the second room, the receiving room.

- The space- and time-averaged sound pressure levels in the two rooms are determined. In addition, with the test specimen in place, the sound absorption in the receiving room is determined.
SOUND INSULATION TESTS

- Testing Procedure

Background Measurement
SOUND INSULATION TESTS

- Testing Procedure

Transmission Loss Measurement
SOUND INSULATION TESTS

- Testing Procedure

Reverberation Time Measurement
SOUND INSULATION TESTS

- The sound pressure levels in the two rooms, the sound absorption in the receiving room and the area of the specimen are used to calculate sound transmission loss as shown in the following equation.

- For ASTM E90 and BS EN ISO 140-3:
  
  \[ TL = L_1 - L_2 + 10 \log(S / A) \]

- Because transmission loss is a function of frequency, measurements are made in a series of frequency bands.
SOUND INSULATION TESTS
SOUND INSULATION TESTS

Test Result

$R_w$ Standard Curve

$STC$ Standard Curve
SOUND INSULATION TESTS

- Transom (Vertical room to room)
SOUND INSULATION TESTS

- Transom (Vertical room to room)
SOUND INSULATION TESTS

- Mullion (Horizontal room to room)
SOUND INSULATION TESTS

- Mullion (Horizontal room to room)
PREDICTION MODELS FOR SOUND INSULATION

- Needs for Sound Insulation Prediction

  - Laboratory measurements have been made for many different types of partitions. However, it is impractical to test every possible design

  - To investigate the effects of changes to existing designs

It is necessary to have reliable methods for predicting the sound transmission loss of typical building constructions.
PREDICTION MODELS FOR SOUND INSULATION

- Homogeneous Panels

  - The most important property is the mass per unit area of the panel. The mass law gives a very simple prediction of the transmission loss $TL$

    $$TL = 20\log(mf) - 47$$

  - However, for most practical building materials the static stiffness must be sufficiently high that coincidence between airborne and structure borne waves will occur within the frequency range of interest ($50 - 5,000$ Hz).

  - The mass law is modified to include the change in transmission at the critical frequency and above

    $$TL = 20\log(mf^c) - 10\log(2\eta\omega / \pi\omega_c) - 47$$
PREDICTION MODELS FOR SOUND INSULATION

- Homogeneous Panels

  For most thin homogeneous materials used in building construction, above equation provides an excellent prediction of the transmission loss over most of the frequency range.

  However, one additional effect must be taken into account to obtain good accuracy at low frequencies. For typical test construction of 10 – 12 m², the radiation efficiency of forced waves must be taken into account for frequencies of less than 200Hz. Sewell gives the correction to the infinite area panel as

\[
\Delta TL = -10 \log[\ln( kA^{1/2})] + 20 \log[1 - (\omega/\omega_c)^2]
\]
PREDICTION MODELS FOR SOUND INSULATION

- Double Panels

  - Many walls and floors are constructed of thin linings with an air space between, and these can, if correctly designed, give high sound transmission loss.

  - For a partition consisting of two thin homogeneous panels, separated by an air gap containing an acoustically absorbing blanket, and with no interconnections between the two panels. Sharp has developed expressions for the transmission loss in 3 frequency ranges as follows:

    \[
    TL = 20 \log[f(m_1 + m_2)] - 47 \quad \cdots f < f_0
    \]
    \[
    TL = TL_1 + TL_2 + 20 \log(fd) - 29 \quad \cdots f_0 < f < f_1
    \]
    \[
    TL = TL_1 + TL_2 + 6 \quad \cdots f > f_1
    \]
PREDICTION MODELS FOR SOUND INSULATION

- Double Panels

- These expressions do not contain any parameters to describe the variation in performance due to different acoustic absorbers in the airspace and it is a practical problem of some interest to determine this effect. Fahy gives an alternative high frequency solution.

\[ TL = TL_1 + TL_2 + 8.6 \alpha d + 20 \log(\beta / k) \quad \cdots f > f_1 \]
PREDICTION MODELS FOR SOUND INSULATION

- Double Panels

- While some constructions can approach the ideal of double panels without interconnections, in practice most construction will have some type of solid or resilient connection between the panels. Sharp has developed relatively simple expressions for the transmission loss of double panels with either point or line interconnections.

\[
TL = TL_{1+2} + 20 \log(e \cdot f_c) + 20 \log[m_1 / (m_1 + m_2)] - 45
\]

\[
TL = TL_{1+2} + 20 \log(b \cdot f_c) + 20 \log[m_1 / (m_1 + m_2)] - 18
\]
INSUL SOUND INSULATION PREDICTION

**INSUL**

For predicting the airborne sound insulation of walls, floors and glazing, impact sound insulation of floors and rain noise

**INSUL - Features**

- Database of common builderswork materials and floor coverings
- Material parameters are user definable
- Composite Transmission Loss calculator
- Leakage calculation
- Standalone or network license available.

- Languages selectable: English, French, German, Spanish, Polish
- Calculation range 50–5000 Hz
- Absorption materials user definable
- English or Metric units
- Indoor to Outdoor calculator
INSUL SOUND INSULATION PREDICTION
INSUL SOUND INSULATION PREDICTION

Sound Insulation Performance
Double Glazing Partition System: 6mm Glass + 68mm Air Gap + 8mm Glass

- Test result
- INSUL

Sound Transmission Loss (TL), dB

Frequency, Hz

100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000
INSUL SOUND INSULATION PREDICTION

Sound Insulation Performance
Triple Glazing System: 10mm Glass + 150mm Air Gap + 10mm Glass + 12mm Air Gap + 8mm Glass

- Measured result
- INSUL
INSUL SOUND INSULATION PREDICTION

Sound insulation performance
- lined brickwork -

Sound insulation performance
- plasterboard partition with timber studs -
INSUL SOUND INSULATION PREDICTION

Sound insulation performance
- twin frame wall -

Sound insulation performance
- concrete floor with suspended ceiling -
INSUL SOUND INSULATION PREDICTION
TO ACHIEVE HIGH SOUND INSULATION

- Increase thickness of single panes (to increase mass).

- Use laminated glass to reduce the coincidence effect. Laminated glass can achieve STC rating 3 or more higher than monolithic glass of identical thickness.

- Use double-glass construction with at least 1/2-in-wide spacing between panes of different thickness (so panes will have different resonant frequencies). Ratio of thicknesses should be about 2:1. Replacing one pane of glass with equal thickness of laminated glass increases STC by 4.
TO ACHIEVE HIGH SOUND INSULATION

- Increase spacing between panes up to 6 in. TL increases by about 3 dB per doubling of mean separation distance.

- Avoid using lightweight frames, and where especially high TL is required, use separate frames to reduce flanking of sound energy.

- Line interior perimeter of frame with sound-absorbing treatment (to improve TL by 2 to 5 dB at high frequencies).

- Mount panes with soft neoprene edge gaskets, which provide higher TL than putty or caulking for the same thickness of glazing.
CONCLUSION

- Any prediction tools are not a substitute for actual test/measurement,
  - Extensive comparisons with test data indicate that INSUL can reliably predict $R_w / STC$ values to within 3dB for most constructions.
  - In practical, some building constructions are too complicated to predict.

- However, the sound insulation performance can be predicted with acceptable engineering accuracy over the frequency range 50-5,000 Hz using simple and readily available expressions.
Thank You!

Q & A