Automated Shape Adjustment of Interlocking Joints for Structurally Informed Design of Masonry Block Assemblages

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SiDMACIB

Structurally informed Design of Masonry Assemblages Composed of Interlocking Blocks

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lock geometric properties \quad \leftrightarrow \quad Interface sliding resistance

Orthotropic sliding resistance

lock shear friction
Automatic lock orientation adjustment → Remove the sliding infeasibility
1. Static problem for corrugated interfaces

2. Sliding infeasibility measurement

3. Lock-orientation optimization
1. Static problem for corrugated interfaces

2. Sliding infeasibility measurement

3. Lock-orientation optimization
1. Static problem for corrugated interfaces

Stacked bond pattern

Running bond pattern
1. Static problem for corrugated interfaces
A single block with a horizontal rigid joint

Rigid joint (rj)
Peripheral joint (pj)

Two interlocking blocks

\[
\begin{align*}
\vec{r}_{pj,n} &\leq 0 & \text{compression constraint} \\
|\vec{r}_{pj,t1}| &\leq \mu |\vec{r}_{pj,n}| & \text{friction constraint} \\
|\vec{r}_{pj,t2}| &\leq 0.33 T_0 & \text{shear constraint}
\end{align*}
\]
1. Static problem for corrugated interfaces

\[ C_{eq,\theta} \cdot \vec{r} + \vec{E} = 0 \]

subjected to:

\[ r_{pj,n} \leq 0 \]  \hspace{1cm} \text{compression constraint}

\[ |r_{pj,t1}| \leq \mu |r_{pj,n}| \]  \hspace{1cm} \text{friction constraint}

\[ |r_{pj,t2}| \leq 0.33 T_0 \]  \hspace{1cm} \text{shear constraint}

Equilibrium equation
1. Static problem for corrugated interfaces

2. Sliding infeasibility measurement

3. Lock-orientation optimization
1. Static problem for corrugated interfaces

\[ C_{eq,\theta} \cdot \vec{r} + \vec{E} = 0 \]

subjected to:

\[ r_{pj,n} \leq 0 \]

Equilibrium equation

\[ r_{pj,t1} \leq \mu r_{pj,n} \]

Compression constraint

\[ r_{pj,t2} \leq 0.33 T_0 \]

Friction constraint

\[ r_{pj,t3} \leq 0 \]

Shear constraint
2. Sliding infeasibility measurement

\[ SIM = f (r_{1}^{pj,t2}) + f (r_{4}^{pj,t2}) \]

Equilibrium equation

\[ c_{eq, \theta} \cdot \bar{r} + \bar{E} = 0 \]

subjected to:

| Compression constraint |
|------------------------|
| \( \bar{r}^{pj,n} \leq 0 \) |

| Friction constraint |
|---------------------|
| \( \bar{r}^{pi,t1} \leq \mu \bar{r}^{pi,n} \) |

| Shear constraint |
|------------------|
| \( \bar{r}^{pj,t2} \leq 0.33 T_0 \) |
2. Sliding infeasibility measurement
2. Sliding infeasibility measurement

Constrained
2. Sliding infeasibility measurement

Unconstrained
2. Sliding infeasibility measurement

\[ SIM_\theta = \min \sum_{\eta=1}^{L} \left[ \left( r_{\eta}^{pj,t1b} \right)^2 + \left( r_{\eta}^{pj,t2b} \right)^2 \right] \]

Objective function
2. Sliding infeasibility measurement

\[
SIM_\theta = \min \sum_{\eta=1}^{L} \left[ \left( r_{\eta}^{pjt1b} \right)^2 + \left( r_{\eta}^{pjt2b} \right)^2 \right]
\]

subjected to:

\[
C_{eq,\theta} \cdot \vec{r} + \vec{E} = 0
\]

\[
\frac{r_{pj,n}}{r_{pj,n}} \leq 0
\]

\[
|\frac{r_{pj,t1a}}{r_{pj,t1a}}| \leq \mu |\frac{r_{pj,n}}{r_{pj,n}}|
\]

\[
|\frac{r_{pj,t2a}}{r_{pj,t2a}}| \leq 0.33 T_0
\]

Objective function

Equilibrium equation

compression constraint

friction constraint

shear constraint
2. Sliding infeasibility measurement

Feasible model: $SIM = 0$

Infeasible model: $SIM > 0$
1. Static problem for corrugated interfaces

2. Sliding infeasibility measurement

3. Lock-orientation optimization
3. Lock-orientation optimization
3. Lock-orientation optimization

- Lock orientation
- Geometric properties
- Material properties

SIA Function

SIM
3. Lock-orientation optimization

- Lock orientation $\theta$
- Geometric properties
- Material properties

SIA ($\theta$)

SIM
3. Lock-orientation optimization

Min SIA (θ)
3. Lock-orientation optimization

![Diagram showing lock orientation optimization](image)

- **SIM (N^2)**
- **Lock orientation (rad)**

[Graph illustrating the relationship between SIM and lock orientation]
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Thank you!

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