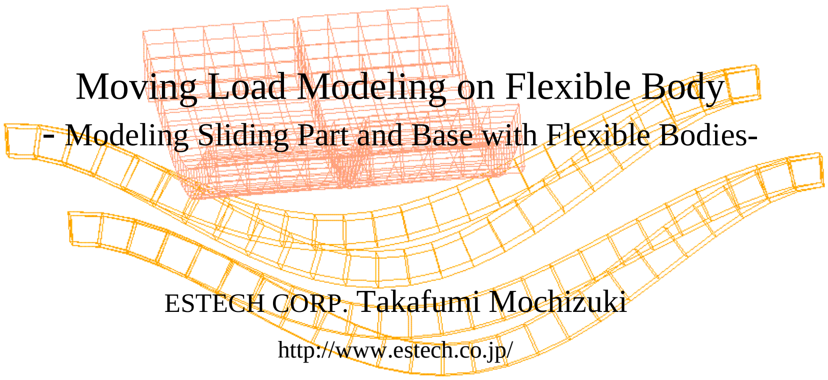

Moving Load Modeling on Flexible Body

- Modeling Sliding Part and Base with Flexible Bodies-

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ABSTRACT

In order to model mechanism parts as rigid bodies, constraints that are available with ADAMS can be used. Furthermore, if the flexibility characteristic of a part is important, modeling by ADAMS/Flex is necessary. However in real systems, most of the mechanism structures transmit power while in motion, and points at which force is being transmitted change at every moment during the operation.

Method to model moving load on a flexible body was developed by the authors as this modeling technique is not available with currently available ADAMS. This paper presents the application of the developed method where a sliding part and a base part were both modeled as flexible bodies.

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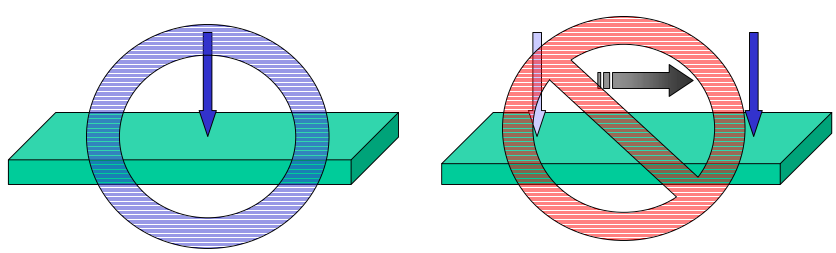
Background

- Analysis of positioning accuracy of a precision machine under working condition
- This machine has a table (sliding mechanism).
- The effect of own weight on deformation while the table is moving is considerable.

ADAMS at present

Force applied on node = Yes   Force moving on flexible body = No



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Modeling scheme

- Flexible body motion is divided into rigid body motion and elastic deformation.
- Moving load is divided into force applied on rigid body and modal force causing elastic deformation.
- Mode shape used for calculating modal force is expressed in a function of location.

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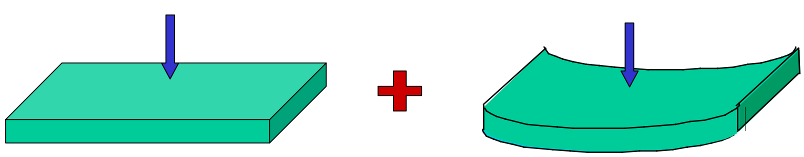
Expression of moving load

Force applied on structure	Force causing elastic deformation
Physical force on rigid part	Modal force



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Modal force

$[M_m]\{\ddot{q}\} + [K_m]\{q\} = \{F_m\}$
$\{x\} = [\Phi]\{q\}$
$\{F_m\} = [\Phi]^T\{F\}$

$[M_m]$	:Modal mass
$[K_m]$	:Modal stiffness
$\{q\}$	:Modal DOF
$\{F_m\}$	:Modal force
$[\Phi]$	:Mode shapes
$\{x\}$	:Physical DOF

- Forces causing elastic deformation can be expressed as modal forces in each mode.
- Each modal force is defined by physical force applied on structure and by mode shape at the location and direction of applied load.

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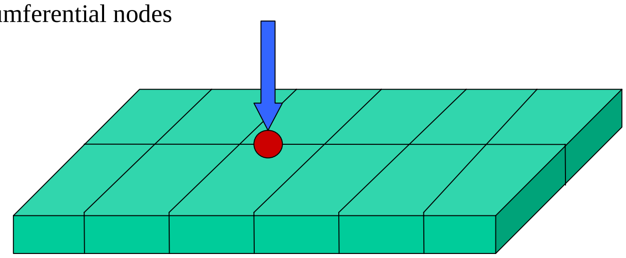
Mode shape

- Calculate the location of instantaneous acting point
- Mode shape at the acting point is obtained by interpolating mode shape at circumferential nodes



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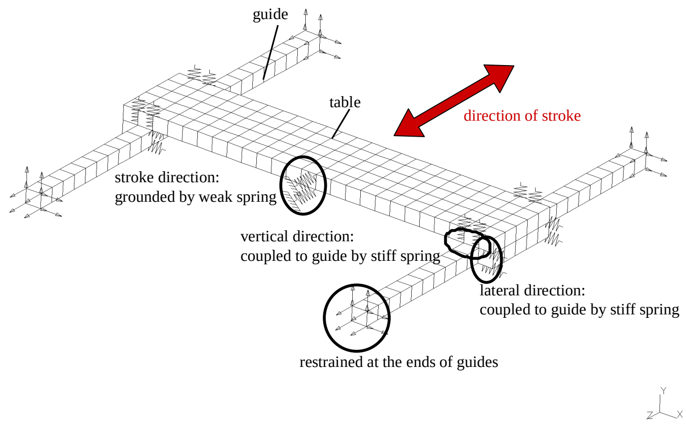
Validation model



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Validation

- Comparison between ADAMS with this procedure and FEM analysis
  - Static deformation by gravity with different table locations
  - Entire eigen mode change with different table locations

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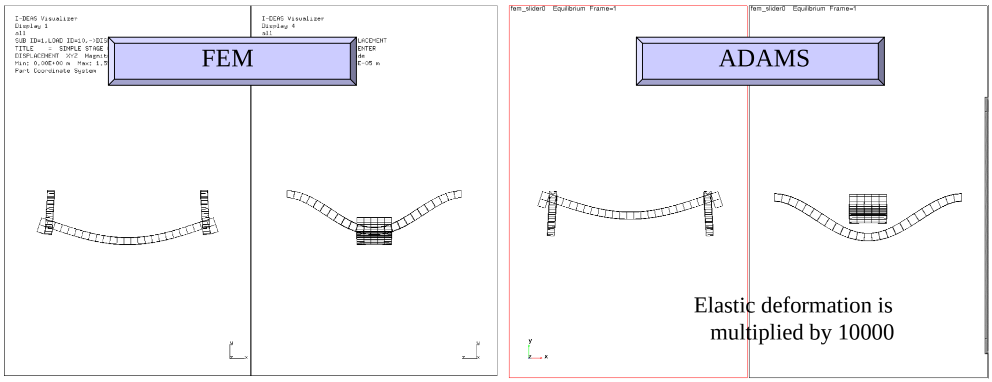
Deformation by gravity



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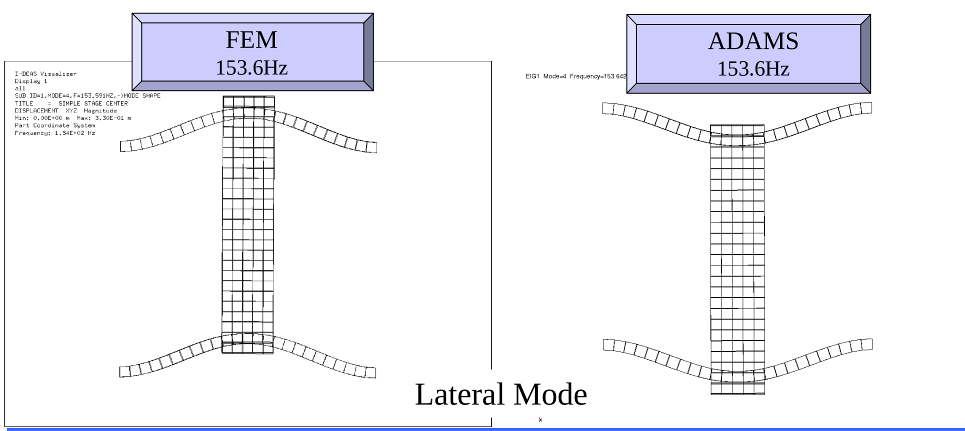
Eigen frequency (table location : center)



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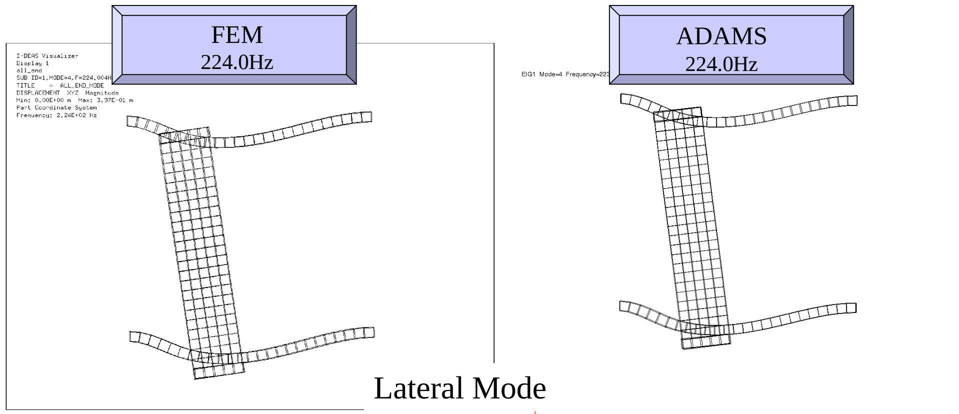
Eigen frequency (table location : far end)



Lateral Mode

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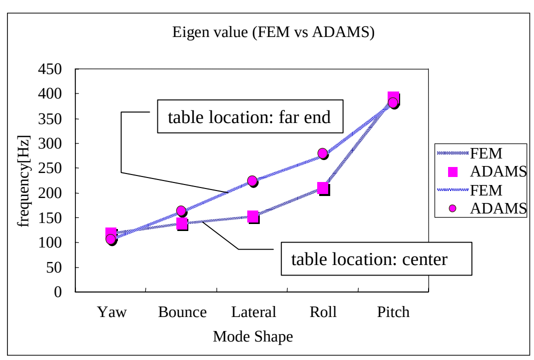
Validation results

- Changes in the mode of deformation caused by self weight corresponding to different table location were well reproduced.
  - (Difference in deformation with FEM was under 0.1%)
- Changes in the entire eigen mode corresponding to different table location were well reproduced.
  - (Difference in frequency with FEM was under 2%)



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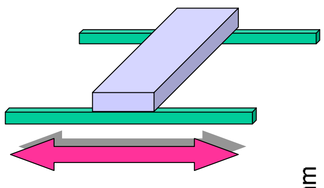
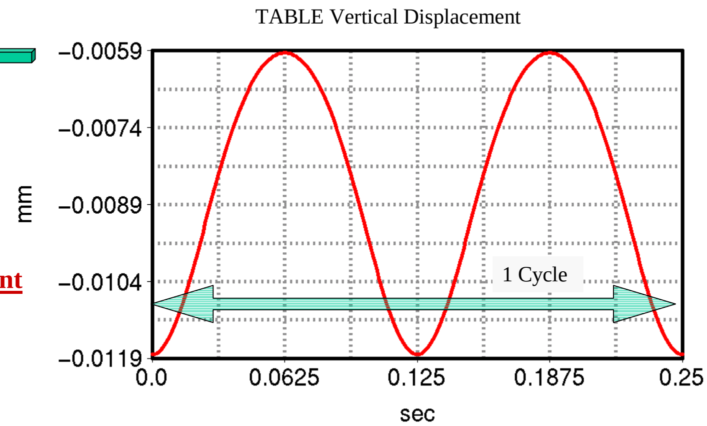
Results of analysis

shuttle between both ends



Sinusoidal movement



Two vertical displacement occurred within 1 cycle

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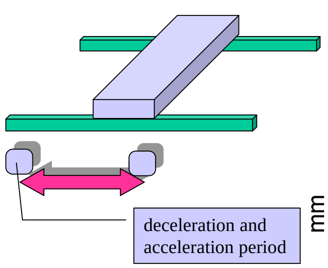
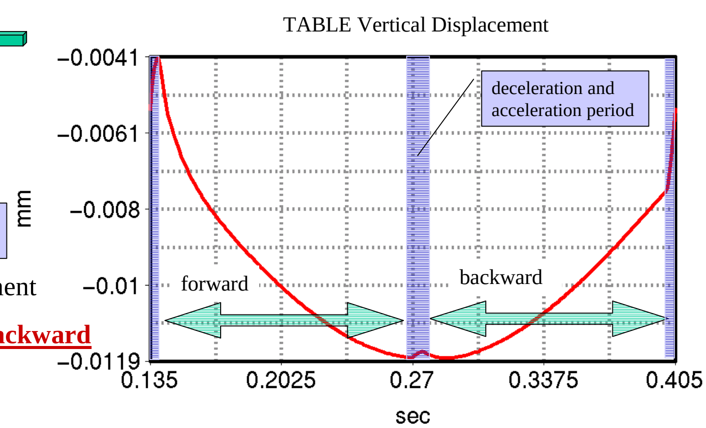
Results of analysis

constant speed movement between center and one end



Constant speed movement



Different response for backward and forward movement

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Conclusion

- Method to model moving load on a Flexible body was developed.
- This method was applied to sliding mechanism between two flexible bodies
- The importance of non-linear characteristic caused by movement of the point of force transmission was made clear.

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