Generative design approach

Throughout this section, the code written for the purposes of this thesis is discussed in detail. The code is extensive and lengthy. Details considered trivial or irrelevant are left out of the discussion. The entirety of the code is accessible to the reader and is extensively commented for clarification.

Template

A template model is initially created. The template can be altered according to the specified design methodology applied. The template contains all necessary information and all appropriate FEM settings have been applied. This decreases the need for alterations later.

Template parameters need to be specified by the user. An overview of the user-specified template parameters is given in Table below.

|  |  |
| --- | --- |
| Variable | Description |
| case | The template case identifier |
| x\_e | The number of elements in the x-direction |
| y\_e | The number of elements in the y-direction |
| e\_s | The side length of the element in mm |
| b | The number of elements reserved for the unit boundary width |
| n\_steps | The number of analysis steps in the second of analysis |
| table\_name | The name of the function applied to the template |
| app | The dimensions of the applied boundary conditions |

The template case identifier refers to one of three deformation cases applied to the template. These cases are discussed in detail in Section.

The user-specified template parameters are used to define a template class object. The template class object calculates more parameters used in the construction of the template. The relevant calculated parameters are outlined in Table below.

|  |  |  |
| --- | --- | --- |
| Variable | Calculation | Description |
| x\_s | e\_s\*x\_e | The side length of the template in mm in the x-direction |
| y\_s | e\_s\*y\_e | The side length of the template in mm in the y-direction |
| ogd\_mat |  | The non-linear Ogden material model |
| x\_n | x\_e + 1 | The number of nodes in the x-direction |
| y\_n | y\_e + 1 | The number of nodes in the y-direction |
| n\_e | x\_e\*y\_e | The total number of elements in the template |
| n\_n | x\_n\*y\_n | The total number of nodes in the template |
| e\_internal |  | The list of internal element IDs that are allowed to be removed |
| n\_external |  | The list of external node IDs that are allowed to be removed |
| t\_id | <case>\_<x\_e>x<y\_e>  \_<x\_s>\_<y\_s> | The template ID |
| grid |  | A representative grid of ones |

The template is then created in MarcMentat. The nodes are created starting at the global origin on the XY-plane. The nodes are incrementally added in the positive x-direction. The nodes are spaced apart as defined by e\_s. Once a row of nodes is completed as defined by x\_n, the y-coordinate is positively incremented as defined by e\_s. A new row of nodes is created. This process is repeated until completed as defined by y\_n.

Four nodes are used to make square 2D elements. Starting at the global origin, elements are incrementally added in the x-direction until completed as defined by x\_e. All rows are added until completed as defined by y\_e.

The graph used to apply the boundary conditions is applied. The boundary conditions are applied according to the case identifier. The boundary conditions related to each case are detailed in section.

Mechanical planar strain geometric properties are added to all elements. The Ogden material model for Mold-Star 15 is applied to all elements. A single contact body is defined containing all elements. The loadcase containing the fixed and forced displacement boundary conditions is created. The job for the loadcase is created.

The template is saved at this point. All units created during a simulation are built from this template.

The template job is run and its success evaluated. The process of running a simulation and evaluating its success is outlined in Section.

Running a Job

The command to run the job is sent to MarcMentat. Jobs may take anywhere from 0.01 seconds to 300 seconds to complete. This depends on the complexity of the model and the number of cut-backs during calculation required to accurately solve for the model behavior.

MarcMentat creates several files during the process of running a job. The log file specifies the exit condition of the job. The log file is not created at the start of the job.

A model is always saved just before a job is run. The timestamp of this saved model is used for evaluation of the log file. It is first determined if the log file exists. If it does not exist, the code waits for 1 second before checking again. This repeats until the log file is found to exist. If the log file is found, its timestamp is compared to the model file’s timestamp. If the log file is older than the model, i.e. it is a log file of a previous run of the model, the code waits 1 second before checking if it has been updated. If the log file is newer than the model, it is inspected for the exit number string or the access violation string.

If the exit number string is found, the exit number is evaluated. Two exit numbers and an error case are identified and defined in Table below.

|  |  |
| --- | --- |
| Exit number | Description |
| 3004 | A successful run |
| 67 | A license server connection time out or failure |
| Other | An unsuccessful run |

If an access violation string is found, it is treated identically to exit number 67.

Cases

Case 1 – Pure elongation

Case 1 is a case of pure elongation as defined by … This case has no rigid body modes. This case has applications in causing extension.

Four boundary conditions are applied. They are outlined in Table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Label | Boundary | Constraint | Direction |
| bc\_fd\_yy1 | Bottom edge | Fixed | y |
| bc\_fd\_yy2 | Top edge | Forced displacement | y |
| bc\_fd\_xx1 | Left edge | Fixed | x |
| bc\_fd\_xx2 | Right edge | Fixed | x |

The boundary conditions as applied in MarcMentat are illustrated in Figure below. The resulting deformation is illustrated in Figure below.

Case 2 – Pure shear

Case 2 is a case of pure shear as defined by … This case has no rigid body modes. This case has applications in causing angular extension or deformation.

Four boundary conditions are applied. They are outlined in Table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Label | Boundary | Constraint | Direction |
| bc\_fd\_xy1 | Bottom edge | Fixed | x |
| bc\_fd\_xy2 | Top edge | Forced displacement | x |
| bc\_fd\_yx1 | Left edge | Fixed | y |
| bc\_fd\_yx2 | Right edge | Fixed | y |

The boundary conditions as applied in MarcMentat are illustrated in Figure below. The resulting deformation is illustrated in Figure below.

Case 3 – Elongation of one side

Case 3 is a case of elongation applied to one side. The opposite side is kept at a fixed length. This case has applications in causing expansion or curling.

Six boundary conditions are applied. They are outlined in Table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Label | Boundary | Constraint | Direction |
| bc\_fd\_yy1 | Bottom edge | Fixed | y |
| bc\_fd\_yy2 | Top edge | Fixed | y |
| bc\_fd\_xf1 | Bottom left corner | Fixed | x |
| bc\_fd\_xf2 | Bottom right corner | Fixed | x |
| bc\_fd\_xn | Top left corner | Forced displacement | x |
| bc\_fd\_xp | Top right corner | Forced displacement | x |

The boundary conditions as applied in MarcMentat are illustrated in Figure below. The resulting deformation is illustrated in Figure below.