

STAPpp

1.0

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Contents

1	Hierarchical Index	1
1.1	Class Hierarchy	1
2	Class Index	3
2.1	Class List	3
3	File Index	5
3.1	File List	5
4	Class Documentation	7
4.1	CBar Class Reference	7
4.1.1	Detailed Description	8
4.1.2	Constructor & Destructor Documentation	8
4.1.2.1	CBar()	9
4.1.2.2	~CBar()	9
4.1.3	Member Function Documentation	9
4.1.3.1	ElementStiffness()	9
4.1.3.2	ElementStress()	9
4.1.3.3	GenerateLocationMatrix()	9
4.1.3.4	Read()	10
4.1.3.5	SizeOfStiffnessMatrix()	10
4.1.3.6	Write()	10
4.2	CBarMaterial Class Reference	11
4.2.1	Detailed Description	12
4.2.2	Member Function Documentation	12

4.2.2.1	Read()	12
4.2.2.2	Write()	12
4.2.3	Member Data Documentation	12
4.2.3.1	Area	12
4.3	CDomain Class Reference	13
4.3.1	Detailed Description	16
4.3.2	Constructor & Destructor Documentation	16
4.3.2.1	CDomain()	16
4.3.2.2	~CDomain()	16
4.3.3	Member Function Documentation	16
4.3.3.1	AllocateMatrices()	16
4.3.3.2	AssembleForce()	16
4.3.3.3	AssembleStiffnessMatrix()	17
4.3.3.4	CalculateColumnHeights()	17
4.3.3.5	CalculateDiagnoalAddress()	17
4.3.3.6	CalculateEquationNumber()	17
4.3.3.7	GetColumnHeights()	17
4.3.3.8	GetDiagonalAddress()	17
4.3.3.9	GetDisplacement()	18
4.3.3.10	GetElementSetList()	18
4.3.3.11	GetElementTypes()	18
4.3.3.12	GetForce()	18
4.3.3.13	GetLoadCases()	18
4.3.3.14	GetMaterialSetList()	18
4.3.3.15	GetMK()	19
4.3.3.16	GetMODEX()	19
4.3.3.17	GetNEQ()	19
4.3.3.18	GetNLCASE()	19
4.3.3.19	GetNLOAD()	19
4.3.3.20	GetNodeList()	19

4.3.3.21	GetNUME()	20
4.3.3.22	GetNUMEG()	20
4.3.3.23	GetNUMMAT()	20
4.3.3.24	GetNUMNP()	20
4.3.3.25	GetNWK()	20
4.3.3.26	GetStiffnessMatrix()	20
4.3.3.27	GetTitle()	21
4.3.3.28	Instance()	21
4.3.3.29	ReadBarElementData()	21
4.3.3.30	ReadData()	21
4.3.3.31	ReadElements()	21
4.3.3.32	ReadLoadCases()	21
4.3.3.33	ReadNodalPoints()	22
4.3.4	Member Data Documentation	22
4.3.4.1	_instance	22
4.3.4.2	ColumnHeights	22
4.3.4.3	DiagonalAddress	22
4.3.4.4	ElementSetList	22
4.3.4.5	ElementTypes	23
4.3.4.6	Force	23
4.3.4.7	Input	23
4.3.4.8	LoadCases	23
4.3.4.9	MaterialSetList	23
4.3.4.10	MK	23
4.3.4.11	MODEX	24
4.3.4.12	NEQ	24
4.3.4.13	NLCASE	24
4.3.4.14	NLOAD	24
4.3.4.15	NodeList	24
4.3.4.16	NUME	24

4.3.4.17	NUMEG	25
4.3.4.18	NUMMAT	25
4.3.4.19	NUMNP	25
4.3.4.20	NWK	25
4.3.4.21	StiffnessMatrix	25
4.3.4.22	Title	25
4.4	CElement Class Reference	26
4.4.1	Detailed Description	27
4.4.2	Constructor & Destructor Documentation	27
4.4.2.1	CElement()	27
4.4.3	Member Function Documentation	28
4.4.3.1	assembly()	28
4.4.3.2	CalculateColumnHeight()	28
4.4.3.3	ElementStiffness()	28
4.4.3.4	ElementStress()	28
4.4.3.5	GenerateLocationMatrix()	29
4.4.3.6	GetElementMaterial()	29
4.4.3.7	GetNodes()	29
4.4.3.8	Read()	29
4.4.3.9	SizeOfStiffnessMatrix()	29
4.4.3.10	Write()	30
4.4.4	Member Data Documentation	30
4.4.4.1	CDomain	30
4.4.4.2	ElementMaterial	30
4.4.4.3	LocationMatrix	30
4.4.4.4	ND	30
4.4.4.5	NEN	31
4.4.4.6	nodes	31
4.5	CLDLTSolver Class Reference	31
4.5.1	Detailed Description	32

4.5.2	Constructor & Destructor Documentation	32
4.5.2.1	CLDLTSolver()	33
4.5.3	Member Function Documentation	33
4.5.3.1	BackSubstitution()	33
4.5.3.2	LDLT()	33
4.5.3.3	Solve()	33
4.6	CLoadCaseData Class Reference	33
4.6.1	Detailed Description	34
4.6.2	Constructor & Destructor Documentation	34
4.6.2.1	CLoadCaseData()	34
4.6.2.2	~CLoadCaseData()	34
4.6.3	Member Function Documentation	34
4.6.3.1	Allocate()	35
4.6.3.2	Read()	35
4.6.3.3	Write()	35
4.6.4	Member Data Documentation	35
4.6.4.1	dof	35
4.6.4.2	load	35
4.6.4.3	nloads	36
4.6.4.4	node	36
4.7	Clock Class Reference	36
4.7.1	Detailed Description	37
4.7.2	Constructor & Destructor Documentation	37
4.7.2.1	Clock()	37
4.7.3	Member Function Documentation	37
4.7.3.1	Clear()	37
4.7.3.2	ElapsedTime()	37
4.7.3.3	Resume()	37
4.7.3.4	Start()	38
4.7.3.5	Stop()	38

4.7.4	Member Data Documentation	38
4.7.4.1	ct_	38
4.7.4.2	st0_	38
4.7.4.3	st1_	38
4.7.4.4	t0_	38
4.7.4.5	t1_	39
4.8	CMaterial Class Reference	39
4.8.1	Detailed Description	39
4.8.2	Member Function Documentation	40
4.8.2.1	Read()	40
4.8.2.2	Write()	40
4.8.3	Member Data Documentation	40
4.8.3.1	E	40
4.8.3.2	nset	40
4.9	CNode Class Reference	41
4.9.1	Detailed Description	41
4.9.2	Constructor & Destructor Documentation	41
4.9.2.1	CNode()	41
4.9.3	Member Function Documentation	42
4.9.3.1	Read()	42
4.9.3.2	Write()	42
4.9.3.3	WriteEquationNo()	42
4.9.3.4	WriteNodalDisplacement()	42
4.9.4	Member Data Documentation	42
4.9.4.1	bcode	43
4.9.4.2	NDF	43
4.9.4.3	NodeNumber	43
4.9.4.4	XYZ	43
4.10	COutputter Class Reference	43
4.10.1	Detailed Description	44

4.10.2	Constructor & Destructor Documentation	45
4.10.2.1	COutputter()	45
4.10.3	Member Function Documentation	45
4.10.3.1	GetOutputFile()	45
4.10.3.2	Instance()	45
4.10.3.3	OutputElementInfo()	45
4.10.3.4	OutputElementStress()	45
4.10.3.5	OutputEquationNumber()	46
4.10.3.6	OutputHeading()	46
4.10.3.7	OutputLoadInfo()	46
4.10.3.8	OutputNodalDisplacement()	46
4.10.3.9	OutputNodeInfo()	46
4.10.3.10	OutputTotalSystemData()	46
4.10.3.11	PrintBarElementData()	47
4.10.3.12	PrintTime()	47
4.10.4	Member Data Documentation	47
4.10.4.1	_instance	47
4.10.4.2	OutputFile	47
4.11	CSolver Class Reference	48
4.11.1	Detailed Description	49
4.11.2	Constructor & Destructor Documentation	49
4.11.2.1	CSolver()	49
4.11.3	Member Function Documentation	49
4.11.3.1	Solve()	49
4.11.4	Member Data Documentation	49
4.11.4.1	FEMData	49

5	File Documentation	51
5.1	/Users/xzhang/GitHub/stappp/src/cpp/Bar.cpp File Reference	51
5.2	/Users/xzhang/GitHub/stappp/src/cpp/Clock.cpp File Reference	51
5.3	/Users/xzhang/GitHub/stappp/src/cpp/Domain.cpp File Reference	52
5.3.1	Function Documentation	53
5.3.1.1	clear()	53
5.4	/Users/xzhang/GitHub/stappp/src/cpp/Element.cpp File Reference	53
5.5	/Users/xzhang/GitHub/stappp/src/cpp/LoadCaseData.cpp File Reference	53
5.6	/Users/xzhang/GitHub/stappp/src/cpp/main.cpp File Reference	54
5.6.1	Function Documentation	55
5.6.1.1	main()	55
5.7	/Users/xzhang/GitHub/stappp/src/cpp/Material.cpp File Reference	55
5.8	/Users/xzhang/GitHub/stappp/src/cpp/Node.cpp File Reference	55
5.9	/Users/xzhang/GitHub/stappp/src/cpp/Outputter.cpp File Reference	56
5.10	/Users/xzhang/GitHub/stappp/src/cpp/Solver.cpp File Reference	57
5.11	/Users/xzhang/GitHub/stappp/src/h/Bar.h File Reference	57
5.12	/Users/xzhang/GitHub/stappp/src/h/Clock.h File Reference	58
5.13	/Users/xzhang/GitHub/stappp/src/h/Domain.h File Reference	59
5.13.1	Function Documentation	60
5.13.1.1	clear()	60
5.14	/Users/xzhang/GitHub/stappp/src/h/Element.h File Reference	60
5.14.1	Function Documentation	61
5.14.1.1	clear()	62
5.15	/Users/xzhang/GitHub/stappp/src/h/LoadCaseData.h File Reference	62
5.16	/Users/xzhang/GitHub/stappp/src/h/Material.h File Reference	63
5.17	/Users/xzhang/GitHub/stappp/src/h/Node.h File Reference	64
5.18	/Users/xzhang/GitHub/stappp/src/h/Outputter.h File Reference	65
5.19	/Users/xzhang/GitHub/stappp/src/h/Solver.h File Reference	65
	Index	67

Chapter 1

Hierarchical Index

1.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

CDomain	13
CElement	26
CBar	7
CLoadCaseData	33
Clock	36
CMaterial	39
CBarMaterial	11
CNode	41
COutputter	43
CSolver	48
CLDLTSolver	31

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

CBar	Bar element class	7
CBarMaterial	Material class for bar element	11
CDomain	Domain class : Define the problem domain	13
CElement	Element base class	26
CLDLTSolver	LDLT solver: A in core solver using skyline storage and column reduction scheme	31
CLoadCaseData	Class LoadData is used to store load data	33
Clock	Clock class for timing	36
CMaterial	Material base class which only define one data member	39
CNode	Node class	41
COutputter	Outputter class is used to output results	43
CSolver	Base class for a solver	48

Chapter 3

File Index

3.1 File List

Here is a list of all files with brief descriptions:

/Users/xzhang/GitHub/stappp/src/cpp/ Bar.cpp	51
/Users/xzhang/GitHub/stappp/src/cpp/ Clock.cpp	51
/Users/xzhang/GitHub/stappp/src/cpp/ Domain.cpp	52
/Users/xzhang/GitHub/stappp/src/cpp/ Element.cpp	53
/Users/xzhang/GitHub/stappp/src/cpp/ LoadCaseData.cpp	53
/Users/xzhang/GitHub/stappp/src/cpp/ main.cpp	54
/Users/xzhang/GitHub/stappp/src/cpp/ Material.cpp	55
/Users/xzhang/GitHub/stappp/src/cpp/ Node.cpp	55
/Users/xzhang/GitHub/stappp/src/cpp/ Outputter.cpp	56
/Users/xzhang/GitHub/stappp/src/cpp/ Solver.cpp	57
/Users/xzhang/GitHub/stappp/src/h/ Bar.h	57
/Users/xzhang/GitHub/stappp/src/h/ Clock.h	58
/Users/xzhang/GitHub/stappp/src/h/ Domain.h	59
/Users/xzhang/GitHub/stappp/src/h/ Element.h	60
/Users/xzhang/GitHub/stappp/src/h/ LoadCaseData.h	62
/Users/xzhang/GitHub/stappp/src/h/ Material.h	63
/Users/xzhang/GitHub/stappp/src/h/ Node.h	64
/Users/xzhang/GitHub/stappp/src/h/ Outputter.h	65
/Users/xzhang/GitHub/stappp/src/h/ Solver.h	65

Chapter 4

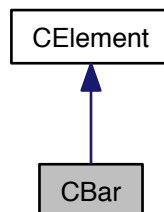
Class Documentation

4.1 CBar Class Reference

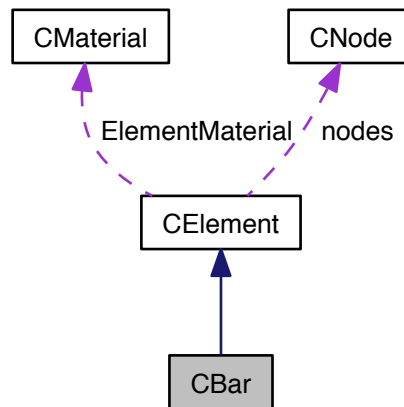
Bar element class.

```
#include <Bar.h>
```

Inheritance diagram for CBar:



Collaboration diagram for CBar:



Public Member Functions

- [CBar](#) ()
Constructor.
- [~CBar](#) ()
Destructor.
- virtual bool [Read](#) (ifstream &Input, int Ele, [CMaterial](#) *MaterialSets, [CNode](#) *NodeList)
Read element data from stream Input.
- virtual void [Write](#) (ofstream &OutputFile, int Ele)
Write element data to stream OutputFile.
- virtual void [GenerateLocationMatrix](#) ()
Generate location matrix: the global equation number that corresponding to each DOF of the element.
- virtual void [ElementStiffness](#) (double *Matrix)
Calculate element stiffness matrix.
- virtual void [ElementStress](#) (double *stress, double *Displacement)
Calculate element stress.
- virtual unsigned int [SizeOfStiffnessMatrix](#) ()
Return the size of the element stiffness matrix (stored as an array column by column)

Additional Inherited Members

4.1.1 Detailed Description

Bar element class.

4.1.2 Constructor & Destructor Documentation

4.1.2.1 CBar()

```
CBar::CBar ( )
```

Constructor.

4.1.2.2 ~CBar()

```
CBar::~~CBar ( )
```

Desconstructor.

4.1.3 Member Function Documentation

4.1.3.1 ElementStiffness()

```
void CBar::ElementStiffness (
    double * Matrix ) [virtual]
```

Calculate element stiffness matrix.

Implements [CElement](#).

4.1.3.2 ElementStress()

```
void CBar::ElementStress (
    double * stress,
    double * Displacement ) [virtual]
```

Calculate element stress.

Implements [CElement](#).

4.1.3.3 GenerateLocationMatrix()

```
void CBar::GenerateLocationMatrix ( ) [virtual]
```

Generate location matrix: the global equation number that corresponding to each DOF of the element.

Implements [CElement](#).

4.1.3.4 Read()

```
bool CBar::Read (
    ifstream & Input,
    int Ele,
    CMaterial * MaterialSets,
    CNode * NodeList ) [virtual]
```

Read element data from stream Input.

Implements [CElement](#).

4.1.3.5 SizeOfStiffnessMatrix()

```
unsigned int CBar::SizeOfStiffnessMatrix ( ) [virtual]
```

Return the size of the element stiffness matrix (stored as an array column by column)

Implements [CElement](#).

4.1.3.6 Write()

```
void CBar::Write (
    ofstream & OutputFile,
    int Ele ) [virtual]
```

Write element data to stream OutputFile.

Implements [CElement](#).

The documentation for this class was generated from the following files:

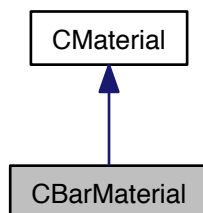
- [/Users/xzhang/GitHub/stapp/src/h/Bar.h](#)
- [/Users/xzhang/GitHub/stapp/src/cpp/Bar.cpp](#)

4.2 CBarMaterial Class Reference

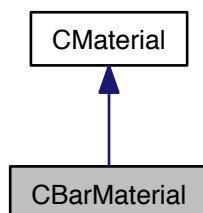
Material class for bar element.

```
#include <Material.h>
```

Inheritance diagram for CBarMaterial:



Collaboration diagram for CBarMaterial:



Public Member Functions

- virtual bool [Read](#) (ifstream &Input, int mset)
Read material data from stream Input.
- virtual void [Write](#) (ofstream &OutputFile, int mset)
Write material data to Stream OutputFile.

Public Attributes

- double [Area](#)
Sectional area of a bar element.

4.2.1 Detailed Description

Material class for bar element.

4.2.2 Member Function Documentation

4.2.2.1 Read()

```
bool CBarMaterial::Read (  
    ifstream & Input,  
    int mset ) [virtual]
```

Read material data from stream *Input*.

Implements [CMaterial](#).

4.2.2.2 Write()

```
void CBarMaterial::Write (  
    ofstream & OutputFile,  
    int mset ) [virtual]
```

Write material data to Stream *OutputFile*.

Implements [CMaterial](#).

4.2.3 Member Data Documentation

4.2.3.1 Area

```
double CBarMaterial::Area
```

Sectional area of a bar element.

The documentation for this class was generated from the following files:

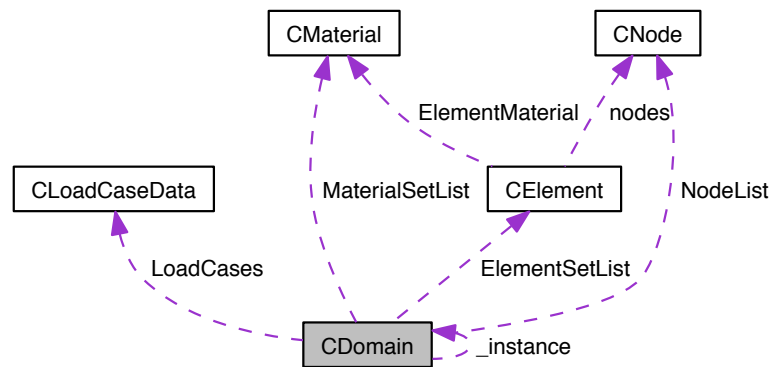
- [/Users/xzhang/GitHub/stapp/src/h/Material.h](#)
- [/Users/xzhang/GitHub/stapp/src/cpp/Material.cpp](#)

4.3 CDomain Class Reference

Domain class : Define the problem domain.

```
#include <Domain.h>
```

Collaboration diagram for CDomain:



Public Member Functions

- [CDomain \(\)](#)
Constructor.
- [~CDomain \(\)](#)
Desconstructor.
- [bool ReadData \(string FileName, string OutFile\)](#)
Read domain data from the input data file.
- [bool ReadNodalPoints \(\)](#)
Read nodal point data.
- [bool ReadLoadCases \(\)](#)
Read load case data.
- [bool ReadElements \(\)](#)
Read element data.
- [bool ReadBarElementData \(int EleGrp\)](#)
Read bar element data from the input data file.
- [void CalculateEquationNumber \(\)](#)
Calculate global equation numbers corresponding to every degree of freedom of each node.
- [void CalculateColumnHeights \(\)](#)
Calculate column heights.
- [void CalculateDiagnoalAddress \(\)](#)
Calculate address of diagonal elements in banded matrix.
- [void AllocateMatrices \(\)](#)
Allocate storage for matrices.
- [void AssembleStiffnessMatrix \(\)](#)
Assemble the banded gloabl stiffness matrix.

- bool [AssembleForce](#) (unsigned int LoadCase)
Assemble the global nodal force vector for load case LoadCase.
- int [GetMODEX](#) ()
Return solution mode.
- string [GetTitle](#) ()
Return the title of problem.
- unsigned int [GetNEQ](#) ()
Return the total number of equations.
- unsigned int [GetNUMNP](#) ()
Return the total number of nodal points.
- unsigned int [GetNWK](#) ()
Return the number of banded global stiffness matrix elements.
- unsigned int [GetMK](#) ()
Return the maximum half bandwidth.
- [CNode](#) * [GetNodeList](#) ()
Return the node list.
- unsigned int * [GetNUME](#) ()
Return the number of elements in each element group.
- unsigned int [GetNUMEG](#) ()
Return total number of element groups.
- unsigned int * [GetElementTypes](#) ()
Element type of each group.
- [CElement](#) ** [GetElementSetList](#) ()
Return element Set List.
- unsigned int * [GetNUMMAT](#) ()
Return number of different sets of material/section properties in each element group.
- [CMaterial](#) ** [GetMaterialSetList](#) ()
Return material set list.
- double * [GetForce](#) ()
Return pointer to the global nodal force vector.
- double * [GetDisplacement](#) ()
Return pointer to the global nodal displacement vector.
- unsigned int [GetNLCASE](#) ()
Return the total number of load cases.
- unsigned int * [GetNLOAD](#) ()
Return the number of concentrated loads applied in each load case.
- [CLoadCaseData](#) * [GetLoadCases](#) ()
Return the list of load cases.
- unsigned int * [GetColumnHeights](#) ()
Return column heights.
- double * [GetStiffnessMatrix](#) ()
Return pointer to the banded stiffness matrix.
- unsigned int * [GetDiagonalAddress](#) ()
Return pointer to the array storing the address of diagonal elements.

Static Public Member Functions

- static [CDomain](#) * [Instance](#) ()
Return pointer to the instance of the Domain class.

Private Attributes

- ifstream [Input](#)
Input file stream for reading data from input data file.
- char [Title](#) [256]
Heading information for use in labeling the output.
- int [MODEX](#)
Solution MODEX.
- unsigned int [NUMNP](#)
Total number of nodal points.
- [CNode](#) * [NodeList](#)
List of all nodes in the domain.
- unsigned int [NUMEG](#)
Total number of element groups.
- unsigned int * [ElementTypes](#)
Element type of each group.
- unsigned int * [NUME](#)
Number of elements in each element group.
- [CElement](#) ** [ElementSetList](#)
Element Set List.
- unsigned int * [NUMMAT](#)
Number of different sets of material/section properties in each element group.
- [CMaterial](#) ** [MaterialSetList](#)
Material set list.
- unsigned int [NLCASE](#)
Number of load cases.
- [CLoadCaseData](#) * [LoadCases](#)
List of all load cases.
- unsigned int * [NLOAD](#)
Number of concentrated loads applied in each load case.
- unsigned int [NEQ](#)
Total number of equations in the system.
- unsigned int [NWK](#)
Number of elements in banded global stiffness matrix.
- unsigned int [MK](#)
Maximum half bandwidth.
- double * [StiffnessMatrix](#)
Banded stiffness matrix.
- unsigned int * [ColumnHeights](#)
Column heights.
- unsigned int * [DiagonalAddress](#)
Address of diagonal elements in banded stiffness matrix.
- double * [Force](#)
Global nodal force/displacement vector.

Static Private Attributes

- static [CDomain](#) * [_instance](#) = NULL
The instance of the Domain class.

4.3.1 Detailed Description

Domain class : Define the problem domain.

Only a single instance of Domain class can be created

4.3.2 Constructor & Destructor Documentation

4.3.2.1 CDomain()

```
CDomain::CDomain ( )
```

Constructor.

4.3.2.2 ~CDomain()

```
CDomain::~~CDomain ( )
```

Desconstructor.

4.3.3 Member Function Documentation

4.3.3.1 AllocateMatrices()

```
void CDomain::AllocateMatrices ( )
```

Allocate storage for matrices.

Allocate Force, ColumnHeights, DiagonalAddress and StiffnessMatrix and calculate the column heights and address of diagonal elements

4.3.3.2 AssembleForce()

```
bool CDomain::AssembleForce (
    unsigned int LoadCase )
```

Assemble the global nodal force vector for load case LoadCase.

4.3.3.3 AssembleStiffnessMatrix()

```
void CDomain::AssembleStiffnessMatrix ( )
```

Assemble the banded gloabl stiffness matrix.

4.3.3.4 CalculateColumnHeights()

```
void CDomain::CalculateColumnHeights ( )
```

Calculate column heights.

4.3.3.5 CalculateDiagnoalAddress()

```
void CDomain::CalculateDiagnoalAddress ( )
```

Calculate address of diagonal elements in banded matrix.

4.3.3.6 CalculateEquationNumber()

```
void CDomain::CalculateEquationNumber ( )
```

Calculate global equation numbers corresponding to every degree of freedom of each node.

4.3.3.7 GetColumnHeights()

```
unsigned int* CDomain::GetColumnHeights ( ) [inline]
```

Return column heights.

4.3.3.8 GetDiagonalAddress()

```
unsigned int* CDomain::GetDiagonalAddress ( ) [inline]
```

Return pointer to the array storing the address of diagonal elements.

4.3.3.9 GetDisplacement()

```
double* CDomain::GetDisplacement ( ) [inline]
```

Return pointer to the global nodal displacement vector.

4.3.3.10 GetElementSetList()

```
CElement** CDomain::GetElementSetList ( ) [inline]
```

Return element Set List.

4.3.3.11 GetElementTypes()

```
unsigned int* CDomain::GetElementTypes ( ) [inline]
```

Element type of each group.

4.3.3.12 GetForce()

```
double* CDomain::GetForce ( ) [inline]
```

Return pointer to the global nodal force vector.

4.3.3.13 GetLoadCases()

```
CLoadCaseData* CDomain::GetLoadCases ( ) [inline]
```

Return the list of load cases.

4.3.3.14 GetMaterialSetList()

```
CMaterial** CDomain::GetMaterialSetList ( ) [inline]
```

Return material set list.

4.3.3.15 GetMK()

```
unsigned int CDomain::GetMK ( ) [inline]
```

Return the maximum half bandwidth.

4.3.3.16 GetMODEX()

```
int CDomain::GetMODEX ( ) [inline]
```

Return solution mode.

4.3.3.17 GetNEQ()

```
unsigned int CDomain::GetNEQ ( ) [inline]
```

Return the total number of equations.

4.3.3.18 GetNLCASE()

```
unsigned int CDomain::GetNLCASE ( ) [inline]
```

Return the total number of load cases.

4.3.3.19 GetNLOAD()

```
unsigned int* CDomain::GetNLOAD ( ) [inline]
```

Return the number of concentrated loads applied in each load case.

4.3.3.20 GetNodeList()

```
CNode* CDomain::GetNodeList ( ) [inline]
```

Return the node list.

4.3.3.21 GetNUME()

```
unsigned int* CDomain::GetNUME ( ) [inline]
```

Return the number of elements in each element group.

4.3.3.22 GetNUMEG()

```
unsigned int CDomain::GetNUMEG ( ) [inline]
```

Return total number of element groups.

4.3.3.23 GetNUMMAT()

```
unsigned int* CDomain::GetNUMMAT ( ) [inline]
```

Return number of different sets of material/section properties in each element group.

4.3.3.24 GetNUMNP()

```
unsigned int CDomain::GetNUMNP ( ) [inline]
```

Return the total number of nodal points.

4.3.3.25 GetNWK()

```
unsigned int CDomain::GetNWK ( ) [inline]
```

Return the number of banded global stiffness matrix elements.

4.3.3.26 GetStiffnessMatrix()

```
double* CDomain::GetStiffnessMatrix ( ) [inline]
```

Return pointer to the banded stiffness matrix.

4.3.3.27 GetTitle()

```
string CDomain::GetTitle ( ) [inline]
```

Return the title of problem.

4.3.3.28 Instance()

```
CDomain * CDomain::Instance ( ) [static]
```

Return pointer to the instance of the Domain class.

4.3.3.29 ReadBarElementData()

```
bool CDomain::ReadBarElementData (
    int EleGrp )
```

Read bar element data from the input data file.

4.3.3.30 ReadData()

```
bool CDomain::ReadData (
    string FileName,
    string OutFile )
```

Read domain data from the input data file.

4.3.3.31 ReadElements()

```
bool CDomain::ReadElements ( )
```

Read element data.

4.3.3.32 ReadLoadCases()

```
bool CDomain::ReadLoadCases ( )
```

Read load case data.

4.3.3.33 ReadNodalPoints()

```
bool CDomain::ReadNodalPoints ( )
```

Read nodal point data.

4.3.4 Member Data Documentation

4.3.4.1 _instance

```
CDomain * CDomain::_instance = NULL [static], [private]
```

The instance of the Domain class.

4.3.4.2 ColumnHeights

```
unsigned int* CDomain::ColumnHeights [private]
```

Column heights.

4.3.4.3 DiagonalAddress

```
unsigned int* CDomain::DiagonalAddress [private]
```

Address of diagonal elements in banded stiffness matrix.

4.3.4.4 ElementSetList

```
CElement** CDomain::ElementSetList [private]
```

Element Set List.

ElementSetList[i] - ith element set

ElementSetList[i][j] - jth element in ith set

4.3.4.5 ElementTypes

```
unsigned int* CDomain::ElementTypes [private]
```

Element type of each group.

4.3.4.6 Force

```
double* CDomain::Force [private]
```

Global nodal force/displacement vector.

4.3.4.7 Input

```
ifstream CDomain::Input [private]
```

Input file stream for reading data from input data file.

4.3.4.8 LoadCases

```
CLoadCaseData* CDomain::LoadCases [private]
```

List of all load cases.

4.3.4.9 MaterialSetList

```
CMaterial** CDomain::MaterialSetList [private]
```

Material set list.

MaterialSetList[i] - ith material set

MaterialSetList[i][j] - jth material in ith set

4.3.4.10 MK

```
unsigned int CDomain::MK [private]
```

Maximum half bandwidth.

4.3.4.11 MODEX

```
int CDomain::MODEX [private]
```

Solution MODEX.

0 : Data check only; 1 : Execution

4.3.4.12 NEQ

```
unsigned int CDomain::NEQ [private]
```

Total number of equations in the system.

4.3.4.13 NLCASE

```
unsigned int CDomain::NLCASE [private]
```

Number of load cases.

4.3.4.14 NLOAD

```
unsigned int* CDomain::NLOAD [private]
```

Number of concentrated loads applied in each load case.

4.3.4.15 NodeList

```
CNode* CDomain::NodeList [private]
```

List of all nodes in the domain.

4.3.4.16 NUME

```
unsigned int* CDomain::NUME [private]
```

Number of elements in each element group.

4.3.4.17 NUMEG

```
unsigned int CDomain::NUMEG [private]
```

Total number of element groups.

An element group consists of a convenient collection of elements with same type

4.3.4.18 NUMMAT

```
unsigned int* CDomain::NUMMAT [private]
```

Number of different sets of material/section properties in each element group.

4.3.4.19 NUMNP

```
unsigned int CDomain::NUMNP [private]
```

Total number of nodal points.

4.3.4.20 NWK

```
unsigned int CDomain::NWK [private]
```

Number of elements in banded global stiffness matrix.

4.3.4.21 StiffnessMatrix

```
double* CDomain::StiffnessMatrix [private]
```

Banded stiffness matrix.

A one-dimensional array storing only the elements below the skyline of the global stiffness matrix.

4.3.4.22 Title

```
char CDomain::Title[256] [private]
```

Heading information for use in labeling the output.

The documentation for this class was generated from the following files:

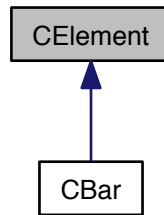
- [/Users/xzhang/GitHub/stappp/src/h/Domain.h](#)
- [/Users/xzhang/GitHub/stappp/src/cpp/Domain.cpp](#)

4.4 CElement Class Reference

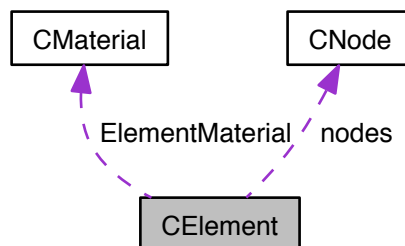
Element base class.

```
#include <Element.h>
```

Inheritance diagram for CElement:



Collaboration diagram for CElement:



Public Member Functions

- [CElement](#) ()
Constructor.
- virtual bool [Read](#) (ifstream &Input, int Ele, [CMaterial](#) *MaterialSets, [CNode](#) *NodeList)=0
Read element data from stream Input.
- virtual void [Write](#) (ofstream &OutputFile, int Ele)=0
Write element data to stream OutputFile.
- virtual void [GenerateLocationMatrix](#) ()=0
Generate location matrix: the global equation number that corresponding to each DOF of the element.
- void [CalculateColumnHeight](#) (unsigned int *ColumnHeight)
Calculate the column height, used with the skyline storage scheme.

- void [assembly](#) (double *Matrix, double *StiffnessMatrix, unsigned int *DiagonalAddress)
Assemble the element stiffness matrix to the global stiffness matrix.
- virtual void [ElementStiffness](#) (double *stiffness)=0
Calculate element stiffness matrix (Upper triangular matrix, stored as an array column by column)
- virtual void [ElementStress](#) (double *stress, double *Displacement)=0
Calculate element stress.
- [CNode](#) ** [GetNodes](#) ()
Return nodes of the element.
- [CMaterial](#) * [GetElementMaterial](#) ()
Return material of the element.
- virtual unsigned int [SizeOfStiffnessMatrix](#) ()=0
Return the size of the element stiffness matrix (stored as an array column by column)

Public Attributes

- friend [CDomain](#)

Protected Attributes

- int [NEN](#)
Number of nodes per element.
- [CNode](#) ** [nodes](#)
Nodes of the element.
- [CMaterial](#) * [ElementMaterial](#)
Material of the element.
- int * [LocationMatrix](#)
Location Matrix of the element.
- int [ND](#)
Dimension of the location matrix.

4.4.1 Detailed Description

Element base class.

All type of element classes should be derived from this base class

4.4.2 Constructor & Destructor Documentation

4.4.2.1 CElement()

```
CElement::CElement ( ) [inline]
```

Constructor.

4.4.3 Member Function Documentation

4.4.3.1 assembly()

```
void CElement::assembly (
    double * Matrix,
    double * StiffnessMatrix,
    unsigned int * DiagonalAddress )
```

Assemble the element stiffness matrix to the global stiffness matrix.

4.4.3.2 CalculateColumnHeight()

```
void CElement::CalculateColumnHeight (
    unsigned int * ColumnHeight )
```

Calculate the column height, used with the skyline storage scheme.

4.4.3.3 ElementStiffness()

```
virtual void CElement::ElementStiffness (
    double * stiffness ) [pure virtual]
```

Calculate element stiffness matrix (Upper triangular matrix, stored as an array column by column)

Implemented in [CBar](#).

4.4.3.4 ElementStress()

```
virtual void CElement::ElementStress (
    double * stress,
    double * Displacement ) [pure virtual]
```

Calculate element stress.

Implemented in [CBar](#).

4.4.3.5 GenerateLocationMatrix()

```
virtual void CElement::GenerateLocationMatrix ( ) [pure virtual]
```

Generate location matrix: the global equation number that corresponding to each DOF of the element.

Implemented in [CBar](#).

4.4.3.6 GetElementMaterial()

```
CMaterial* CElement::GetElementMaterial ( ) [inline]
```

Return material of the element.

4.4.3.7 GetNodes()

```
CNode** CElement::GetNodes ( ) [inline]
```

Return nodes of the element.

4.4.3.8 Read()

```
virtual bool CElement::Read (
    ifstream & Input,
    int Ele,
    CMaterial * MaterialSets,
    CNode * NodeList ) [pure virtual]
```

Read element data from stream Input.

Implemented in [CBar](#).

4.4.3.9 SizeOfStiffnessMatrix()

```
virtual unsigned int CElement::SizeOfStiffnessMatrix ( ) [pure virtual]
```

Return the size of the element stiffness matrix (stored as an array column by column)

Implemented in [CBar](#).

4.4.3.10 Write()

```
virtual void CElement::Write (
    ostream & OutputFile,
    int Ele ) [pure virtual]
```

Write element data to stream *OutputFile*.

Implemented in [CBar](#).

4.4.4 Member Data Documentation

4.4.4.1 CDomain

```
friend CElement::CDomain
```

4.4.4.2 ElementMaterial

```
CMaterial* CElement::ElementMaterial [protected]
```

Material of the element.

Pointer to an element of *MaterialSetList*[][]

4.4.4.3 LocationMatrix

```
int* CElement::LocationMatrix [protected]
```

Location Matrix of the element.

4.4.4.4 ND

```
int CElement::ND [protected]
```

Dimension of the location matrix.

4.4.4.5 NEN

```
int CElement::NEN [protected]
```

Number of nodes per element.

4.4.4.6 nodes

```
CNode** CElement::nodes [protected]
```

Nodes of the element.

The documentation for this class was generated from the following files:

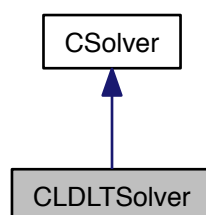
- [/Users/xzhang/GitHub/stapp/src/h/Element.h](#)
- [/Users/xzhang/GitHub/stapp/src/cpp/Element.cpp](#)

4.5 CLDLTSolver Class Reference

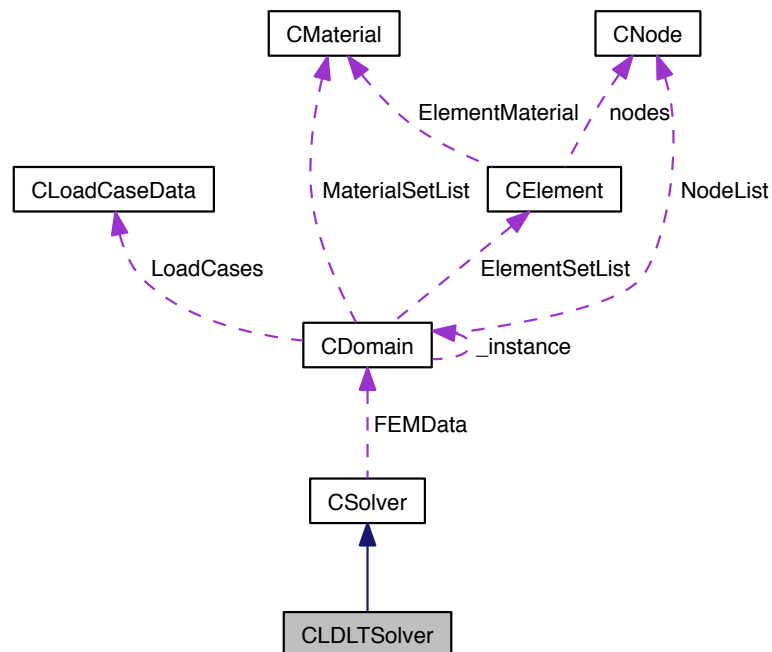
LDLT solver: A in core solver using skyline storage and column reduction scheme.

```
#include <Solver.h>
```

Inheritance diagram for CLDLTSolver:



Collaboration diagram for CLDLTSolver:



Public Member Functions

- [CLDLTSolver](#) ([CDomain](#) *[FEMData](#))
Constructor.
- void [LDLT](#) ()
*Perform $L * D * L(T)$ factorization of the stiffness matrix.*
- void [BackSubstitution](#) ()
Reduce right-hand-side load vector and back substitute.
- virtual void [Solve](#) ()
Solve the equilibrium equations.

Additional Inherited Members

4.5.1 Detailed Description

LDLT solver: A in core solver using skyline storage and column reduction scheme.

4.5.2 Constructor & Destructor Documentation

4.5.2.1 CLDLTSolver()

```
CLDLTSolver::CLDLTSolver (
    CDomain * FEMData ) [inline]
```

Constructor.

4.5.3 Member Function Documentation

4.5.3.1 BackSubstitution()

```
void CLDLTSolver::BackSubstitution ( )
```

Reduce right-hand-side load vector and back substitute.

4.5.3.2 LDLT()

```
void CLDLTSolver::LDLT ( )
```

Perform $L \cdot D \cdot L^T$ factorization of the stiffness matrix.

4.5.3.3 Solve()

```
void CLDLTSolver::Solve ( ) [virtual]
```

Solve the equilibrium equations.

Implements [CSolver](#).

The documentation for this class was generated from the following files:

- [/Users/xzhang/GitHub/stappp/src/h/Solver.h](#)
- [/Users/xzhang/GitHub/stappp/src/cpp/Solver.cpp](#)

4.6 CLoadCaseData Class Reference

Class LoadData is used to store load data.

```
#include <LoadCaseData.h>
```

Public Member Functions

- [CLoadCaseData](#) ()
- [~CLoadCaseData](#) ()
- void [Allocate](#) (int num)
Set nloads, and new array node, dof and load.
- bool [Read](#) (ifstream &Input, int lcase)
Read load case data from stream Input.
- void [Write](#) (ofstream &OutputFile, int lcase)
Write load case data to stream OutputFile.

Public Attributes

- unsigned int [nloads](#)
Number of concentrated loads in this load case.
- unsigned int * [node](#)
Node number to which this load is applied.
- unsigned int * [dof](#)
Degree of freedom number for this load component.
- double * [load](#)
Magnitude of load.

4.6.1 Detailed Description

Class LoadData is used to store load data.

4.6.2 Constructor & Destructor Documentation

4.6.2.1 CLoadCaseData()

```
CLoadCaseData::CLoadCaseData ( ) [inline]
```

4.6.2.2 ~CLoadCaseData()

```
CLoadCaseData::~~CLoadCaseData ( )
```

4.6.3 Member Function Documentation

4.6.3.1 Allocate()

```
void CLoadCaseData::Allocate (
    int num )
```

Set nloads, and new array node, dof and load.

4.6.3.2 Read()

```
bool CLoadCaseData::Read (
    ifstream & Input,
    int lcase )
```

Read load case data from stream Input.

4.6.3.3 Write()

```
void CLoadCaseData::Write (
    ofstream & OutputFile,
    int lcase )
```

Write load case data to stream OutputFile.

4.6.4 Member Data Documentation

4.6.4.1 dof

```
unsigned int* CLoadCaseData::dof
```

Degree of freedom number for this load component.

4.6.4.2 load

```
double* CLoadCaseData::load
```

Magnitude of load.

4.6.4.3 nloads

```
unsigned int CLoadCaseData::nloads
```

Number of concentrated loads in this load case.

4.6.4.4 node

```
unsigned int* CLoadCaseData::node
```

Node number to which this load is applied.

The documentation for this class was generated from the following files:

- [/Users/xzhang/GitHub/stapp/src/h/LoadCaseData.h](#)
- [/Users/xzhang/GitHub/stapp/src/cpp/LoadCaseData.cpp](#)

4.7 Clock Class Reference

[Clock](#) class for timing.

```
#include <Clock.h>
```

Public Member Functions

- [Clock](#) ()
Constructor.
- void [Start](#) ()
Start the clock.
- void [Stop](#) ()
Stop the clock.
- void [Resume](#) ()
Resume the stoped clock.
- void [Clear](#) ()
Clear the clock.
- double [ElapsedTime](#) ()
Return the elapsed time since the clock started.

Private Attributes

- clock_t [t0_](#)
- clock_t [t1_](#)
- double [ct_](#)
- bool [st0_](#)
Flag for Start method.
- bool [st1_](#)
Flag for Stop method.

4.7.1 Detailed Description

[Clock](#) class for timing.

4.7.2 Constructor & Destructor Documentation

4.7.2.1 Clock()

```
Clock::Clock ( )
```

Constructor.

4.7.3 Member Function Documentation

4.7.3.1 Clear()

```
void Clock::Clear ( )
```

Clear the clock.

4.7.3.2 ElapsedTime()

```
double Clock::ElapsedTime ( )
```

Return the elapsed time since the clock started.

4.7.3.3 Resume()

```
void Clock::Resume ( )
```

Resume the stoped clock.

4.7.3.4 Start()

```
void Clock::Start ( )
```

Start the clock.

4.7.3.5 Stop()

```
void Clock::Stop ( )
```

Stop the clock.

4.7.4 Member Data Documentation

4.7.4.1 ct_

```
double Clock::ct_ [private]
```

4.7.4.2 st0_

```
bool Clock::st0_ [private]
```

Flag for Start method.

4.7.4.3 st1_

```
bool Clock::st1_ [private]
```

Flag for Stop method.

4.7.4.4 t0_

```
clock_t Clock::t0_ [private]
```


4.7.4.5 t1_

```
clock_t Clock::t1_ [private]
```

The documentation for this class was generated from the following files:

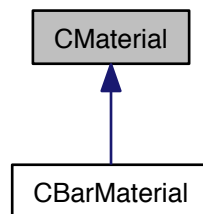
- /Users/xzhang/GitHub/stapp/src/h/[Clock.h](#)
- /Users/xzhang/GitHub/stapp/src/cpp/[Clock.cpp](#)

4.8 CMaterial Class Reference

Material base class which only define one data member.

```
#include <Material.h>
```

Inheritance diagram for CMaterial:



Public Member Functions

- virtual bool [Read](#) (ifstream &Input, int mset)=0
Read material data from stream Input.
- virtual void [Write](#) (ofstream &OutputFile, int mset)=0
Write material data to Stream OutputFile.

Public Attributes

- unsigned int [nset](#)
Number of set.
- double [E](#)
Young's modulus.

4.8.1 Detailed Description

Material base class which only define one data member.

All type of material classes should be derived from this base class

4.8.2 Member Function Documentation

4.8.2.1 Read()

```
virtual bool CMaterial::Read (  
    ifstream & Input,  
    int mset ) [pure virtual]
```

Read material data from stream Input.

Implemented in [CBarMaterial](#).

4.8.2.2 Write()

```
virtual void CMaterial::Write (  
    ofstream & OutputFile,  
    int mset ) [pure virtual]
```

Write material data to Stream OutputFile.

Implemented in [CBarMaterial](#).

4.8.3 Member Data Documentation

4.8.3.1 E

```
double CMaterial::E
```

Young's modulus.

4.8.3.2 nset

```
unsigned int CMaterial::nset
```

Number of set.

The documentation for this class was generated from the following file:

- [/Users/xzhang/GitHub/stappp/src/h/Material.h](#)

4.9 CNode Class Reference

Node class.

```
#include <Node.h>
```

Public Member Functions

- **CNode** (double X=0, double Y=0, double Z=0)
Constructor.
- bool **Read** (ifstream &Input, int np)
Read nodal point data from stream Input.
- void **Write** (ofstream &OutputFile, int np)
Output nodal point data to stream OutputFile.
- void **WriteEquationNo** (ofstream &OutputFile, int np)
Output equation numbers of nodal point to stream OutputFile.
- void **WriteNodalDisplacement** (ofstream &OutputFile, int np, double *Displacement)
Write nodal displacement.

Public Attributes

- unsigned int **NodeNumber**
Node numer.
- double **XYZ** [NDF]
x, y and z coordinates of the node
- int **bcode** [NDF]
Boundary code of each degree of freedom of the node.

Static Public Attributes

- static const unsigned int **NDF** = 3
Maximum number of degrees of freedom per node.

4.9.1 Detailed Description

Node class.

4.9.2 Constructor & Destructor Documentation

4.9.2.1 CNode()

```
CNode::CNode (
    double X = 0,
    double Y = 0,
    double Z = 0 )
```

Constructor.

4.9.3 Member Function Documentation

4.9.3.1 Read()

```
bool CNode::Read (
    ifstream & Input,
    int np )
```

Read nodal point data from stream Input.

4.9.3.2 Write()

```
void CNode::Write (
    ofstream & OutputFile,
    int np )
```

Output nodal point data to stream OutputFile.

4.9.3.3 WriteEquationNo()

```
void CNode::WriteEquationNo (
    ofstream & OutputFile,
    int np )
```

Output equation numbers of nodal point to stream OutputFile.

4.9.3.4 WriteNodalDisplacement()

```
void CNode::WriteNodalDisplacement (
    ofstream & OutputFile,
    int np,
    double * Displacement )
```

Write nodal displacement.

4.9.4 Member Data Documentation

4.9.4.1 bcode

```
int CNode::bcode[NDF]
```

Boundary code of each degree of freedom of the node.

0: The corresponding degree of freedom is active (defined in the global system)

1: The corresponding degree of freedom is nonactive (not defined)

After call `Domain::CalculateEquationNumber()`, `bcode` stores the global equation number corresponding to each degree of freedom of the node

4.9.4.2 NDF

```
const unsigned int CNode::NDF = 3 [static]
```

Maximum number of degrees of freedom per node.

For 3D bar and solid elements, `NDF = 3`. For 3D beam or shell elements, `NDF = 5` or `6`

4.9.4.3 NodeNumber

```
unsigned int CNode::NodeNumber
```

Node number.

4.9.4.4 XYZ

```
double CNode::XYZ[NDF]
```

x, y and z coordinates of the node

The documentation for this class was generated from the following files:

- [/Users/xzhang/GitHub/stapp/src/h/Node.h](#)
- [/Users/xzhang/GitHub/stapp/src/cpp/Node.cpp](#)

4.10 COutputter Class Reference

Outputter class is used to output results.

```
#include <Outputter.h>
```

Collaboration diagram for COutputter:



Public Member Functions

- `ofstream * GetOutputFile ()`
Return pointer to the output file stream.
- `void PrintTime (const struct tm *ptm, ostream &output)`
Output current time and date.
- `void OutputHeading ()`
Output logo and heading.
- `void OutputNodeInfo ()`
Output nodal point data.
- `void OutputEquationNumber ()`
Output equation numbers.
- `void OutputElementInfo ()`
Output element data.
- `void PrintBarElementData (int EleGrp)`
Output bar element data.
- `void OutputLoadInfo ()`
Output load data.
- `void OutputNodalDisplacement (int Icase)`
Output displacement data.
- `void OutputElementStress ()`
Output element stresses.
- `void OutputTotalSystemData ()`
Print total system data.

Static Public Member Functions

- `static COutputter * Instance (string FileName=" ")`
Return the single instance of the class.

Protected Member Functions

- `COutputter (string FileName)`
Constructor.

Static Protected Attributes

- `static COutputter * _instance = NULL`
Designed as a single instance class.

Private Attributes

- `ofstream OutputFile`
File stream for output.

4.10.1 Detailed Description

Outputter class is used to output results.

4.10.2 Constructor & Destructor Documentation

4.10.2.1 COutputter()

```
COutputter::COutputter (
    string FileName ) [protected]
```

Constructor.

4.10.3 Member Function Documentation

4.10.3.1 GetOutputFile()

```
ofstream* COutputter::GetOutputFile ( ) [inline]
```

Return pointer to the output file stream.

4.10.3.2 Instance()

```
COutputter * COutputter::Instance (
    string FileName = " " ) [static]
```

Return the single instance of the class.

4.10.3.3 OutputElementInfo()

```
void COutputter::OutputElementInfo ( )
```

Output element data.

4.10.3.4 OutputElementStress()

```
void COutputter::OutputElementStress ( )
```

Output element stresses.

4.10.3.5 OutputEquationNumber()

```
void COutputter::OutputEquationNumber ( )
```

Output equation numbers.

4.10.3.6 OutputHeading()

```
void COutputter::OutputHeading ( )
```

Output logo and heading.

4.10.3.7 OutputLoadInfo()

```
void COutputter::OutputLoadInfo ( )
```

Output load data.

4.10.3.8 OutputNodalDisplacement()

```
void COutputter::OutputNodalDisplacement (
    int lcase )
```

Output displacement data.

4.10.3.9 OutputNodeInfo()

```
void COutputter::OutputNodeInfo ( )
```

Output nodal point data.

4.10.3.10 OutputTotalSystemData()

```
void COutputter::OutputTotalSystemData ( )
```

Print total system data.

4.10.3.11 PrintBarElementData()

```
void COutputter::PrintBarElementData (
    int EleGrp )
```

Output bar element data.

4.10.3.12 PrintTime()

```
void COutputter::PrintTime (
    const struct tm * ptm,
    ostream & output )
```

Output current time and date.

4.10.4 Member Data Documentation

4.10.4.1 _instance

```
COutputter * COutputter::_instance = NULL [static], [protected]
```

Designed as a single instance class.

4.10.4.2 OutputFile

```
ofstream COutputter::OutputFile [private]
```

File stream for output.

The documentation for this class was generated from the following files:

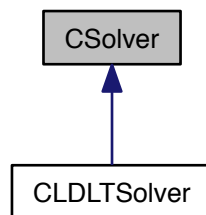
- [/Users/xzhang/GitHub/stapp/src/h/Outputter.h](#)
- [/Users/xzhang/GitHub/stapp/src/cpp/Outputter.cpp](#)

4.11 CSolver Class Reference

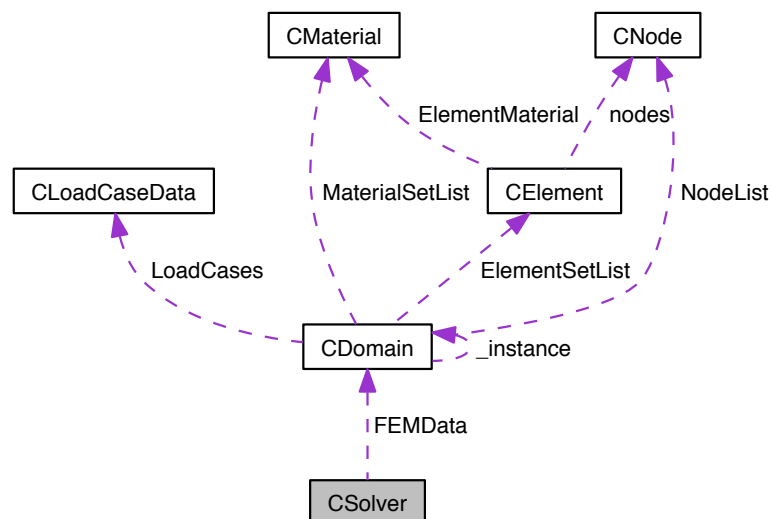
Base class for a solver.

```
#include <Solver.h>
```

Inheritance diagram for CSolver:



Collaboration diagram for CSolver:



Public Member Functions

- [CSolver](#) ([CDomain](#) *[FEMData](#))
- virtual void [Solve](#) ()=0

Protected Attributes

- [CDomain](#) * [FEMData](#)

4.11.1 Detailed Description

Base class for a solver.

4.11.2 Constructor & Destructor Documentation

4.11.2.1 CSolver()

```
CSolver::CSolver (
    CDomain * FEMData )
```

4.11.3 Member Function Documentation

4.11.3.1 Solve()

```
virtual void CSolver::Solve ( ) [pure virtual]
```

Implemented in [CLDLTSolver](#).

4.11.4 Member Data Documentation

4.11.4.1 FEMData

```
CDomain* CSolver::FEMData [protected]
```

The documentation for this class was generated from the following files:

- /Users/xzhang/GitHub/stapp/src/h/[Solver.h](#)
- /Users/xzhang/GitHub/stapp/src/cpp/[Solver.cpp](#)

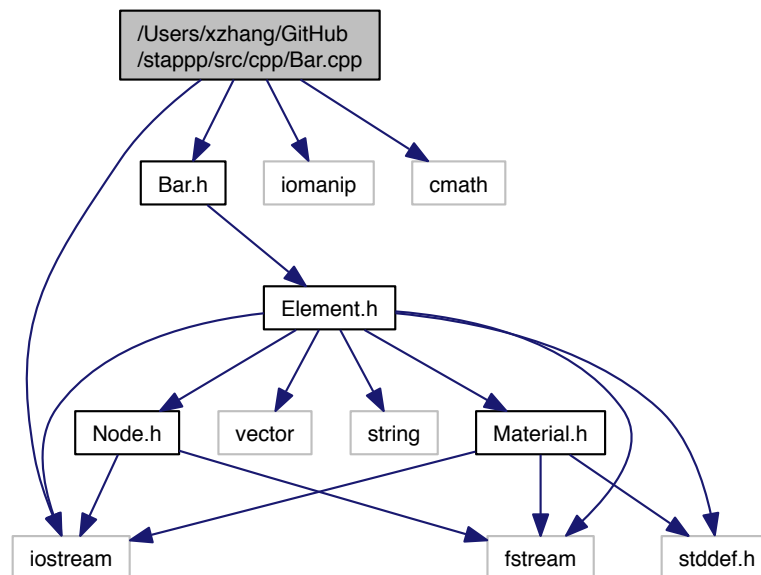
Chapter 5

File Documentation

5.1 /Users/xzhang/GitHub/stappp/src/cpp/Bar.cpp File Reference

```
#include "Bar.h"  
#include <iostream>  
#include <iomanip>  
#include <cmath>
```

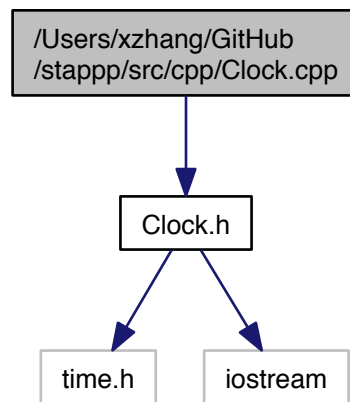
Include dependency graph for Bar.cpp:



5.2 /Users/xzhang/GitHub/stappp/src/cpp/Clock.cpp File Reference

```
#include "Clock.h"
```

Include dependency graph for Clock.cpp:



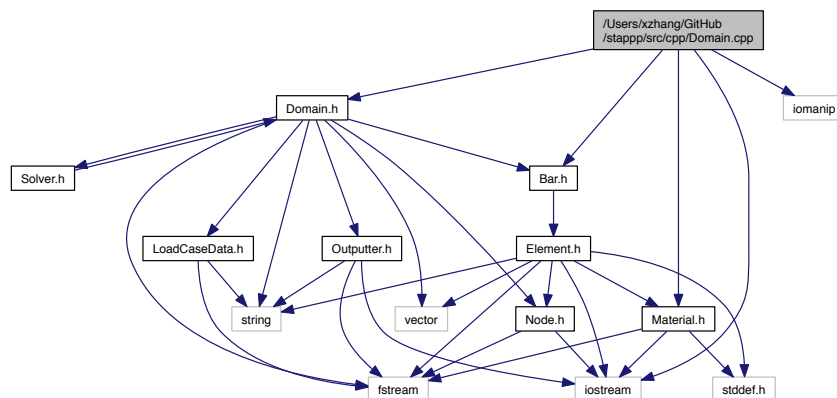
5.3 /Users/xzhang/GitHub/stapp/src/cpp/Domain.cpp File Reference

```

#include "Domain.h"
#include "Bar.h"
#include "Material.h"
#include <iomanip>
#include <iostream>

```

Include dependency graph for Domain.cpp:



Functions

- `template<class type >`
`void clear (type *a, int N)`
Clear an array.

5.3.1 Function Documentation

5.3.1.1 clear()

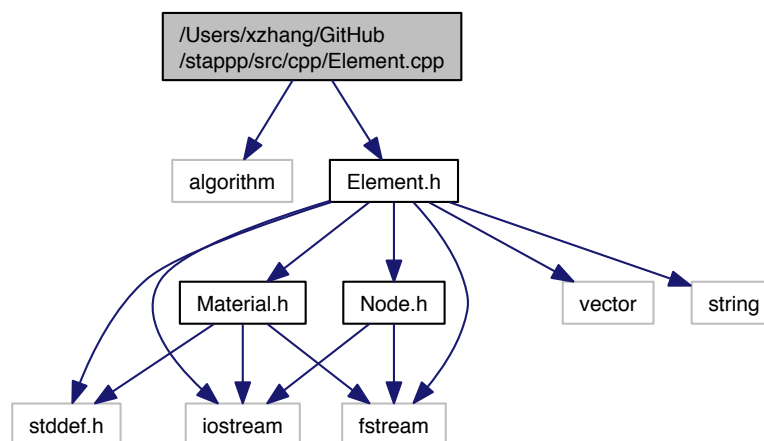
```
template<class type >
void clear (
    type * a,
    int N )
```

Clear an array.

5.4 /Users/xzhang/GitHub/stapp/src/cpp/Element.cpp File Reference

```
#include <algorithm>
#include "Element.h"
```

Include dependency graph for Element.cpp:

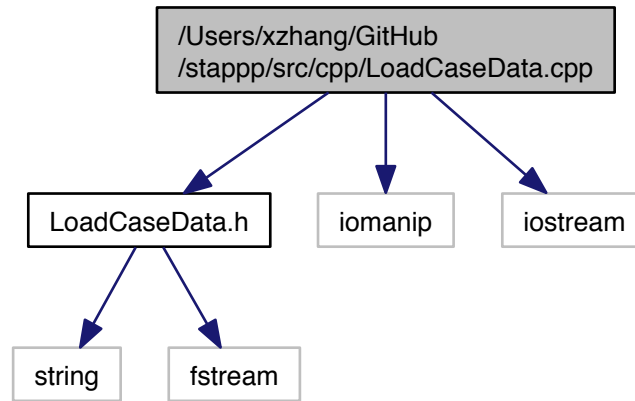


5.5 /Users/xzhang/GitHub/stapp/src/cpp/LoadCaseData.cpp File Reference

```
#include "LoadCaseData.h"
#include <iomanip>
```

```
#include <iostream>
```

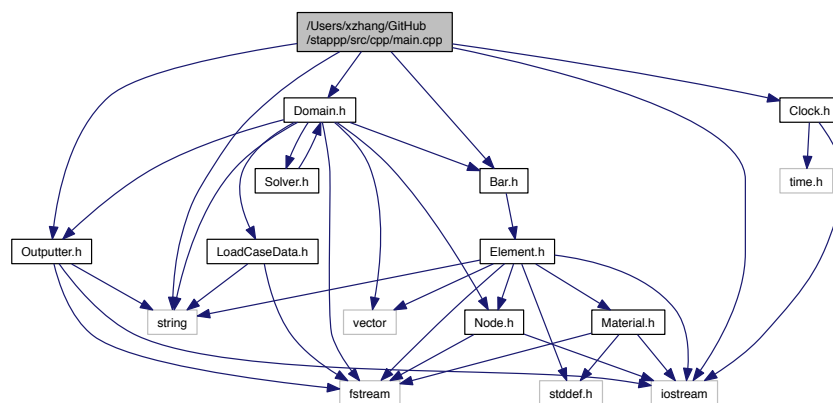
Include dependency graph for LoadCaseData.cpp:



5.6 /Users/xzhang/GitHub/stapp/src/cpp/main.cpp File Reference

```
#include <string>
#include <iostream>
#include "Domain.h"
#include "Bar.h"
#include "Outputter.h"
#include "Clock.h"
```

Include dependency graph for main.cpp:



Functions

- int `main` (int argc, char *argv[])

5.6.1 Function Documentation

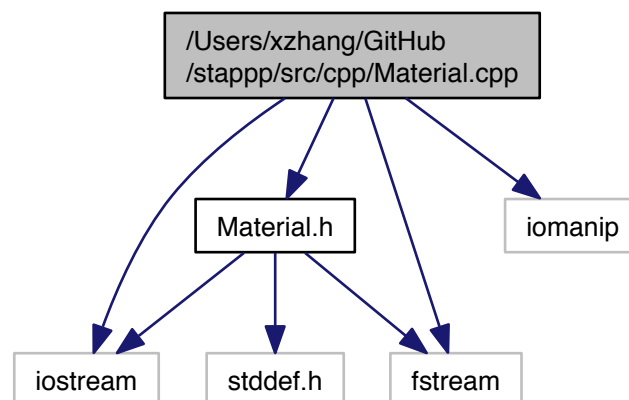
5.6.1.1 main()

```
int main (  
    int argc,  
    char * argv[] )
```

5.7 /Users/xzhang/GitHub/stappp/src/cpp/Material.cpp File Reference

```
#include "Material.h"  
#include <iostream>  
#include <fstream>  
#include <iomanip>
```

Include dependency graph for Material.cpp:

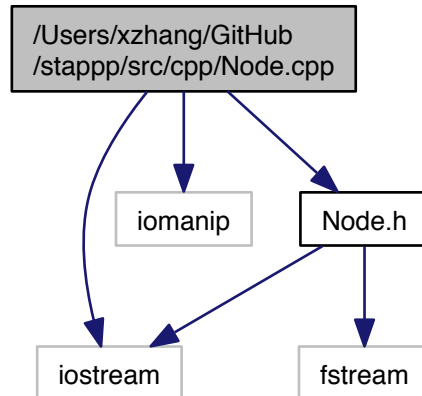


5.8 /Users/xzhang/GitHub/stappp/src/cpp/Node.cpp File Reference

```
#include <iostream>  
#include <iomanip>
```

```
#include "Node.h"
```

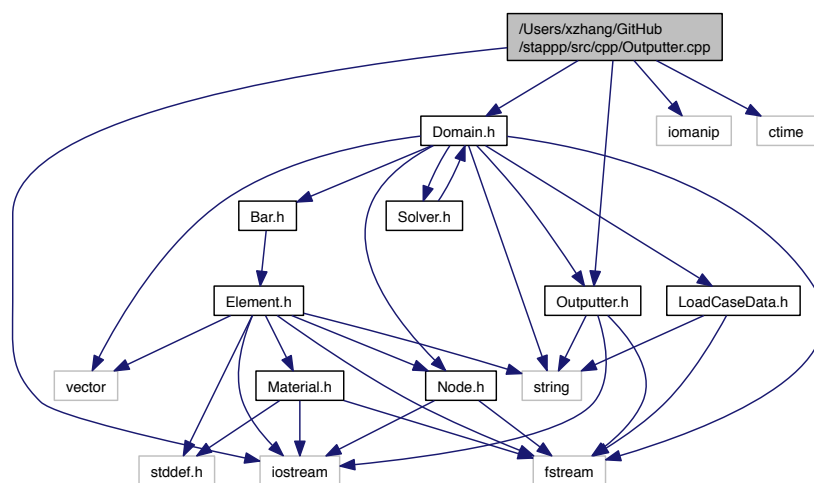
Include dependency graph for Node.cpp:



5.9 /Users/xzhang/GitHub/stapp/src/cpp/Outputter.cpp File Reference

```
#include "Domain.h"
#include "Outputter.h"
#include <iostream>
#include <iomanip>
#include <ctime>
```

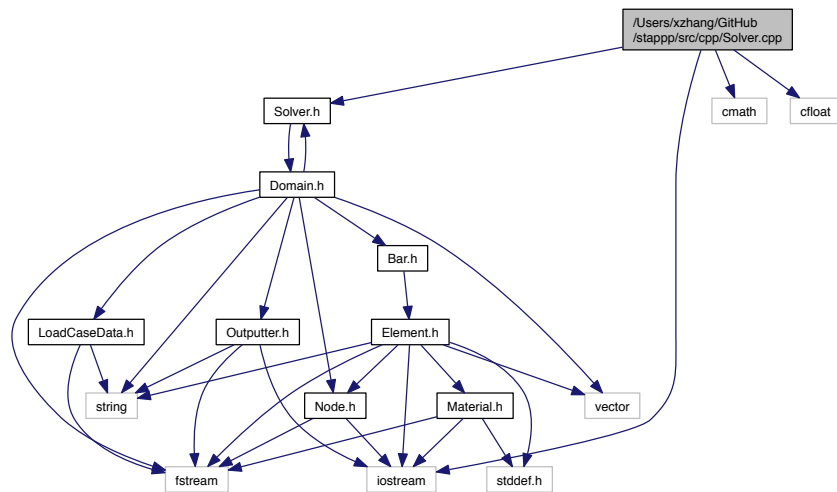
Include dependency graph for Outputter.cpp:



5.10 /Users/xzhang/GitHub/stapp/src/cpp/Solver.cpp File Reference

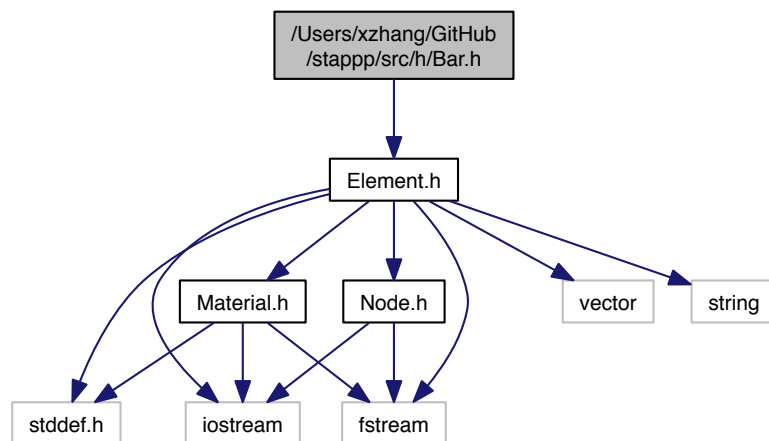
```
#include "Solver.h"
#include <cmath>
#include <cfloat>
#include <iostream>
```

Include dependency graph for Solver.cpp:

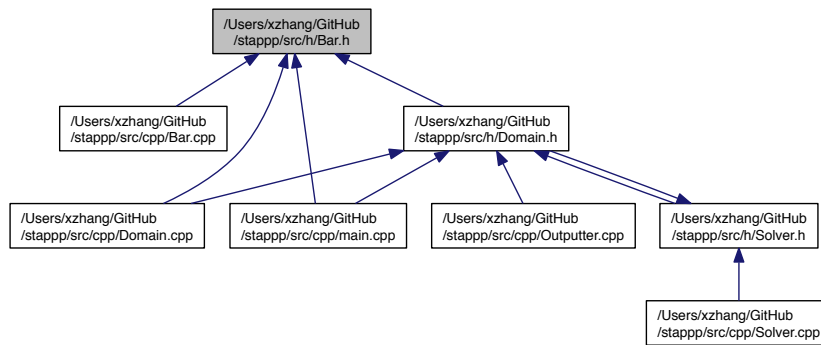


5.11 /Users/xzhang/GitHub/stapp/src/h/Bar.h File Reference

```
#include "Element.h"
Include dependency graph for Bar.h:
```



This graph shows which files directly or indirectly include this file:



Classes

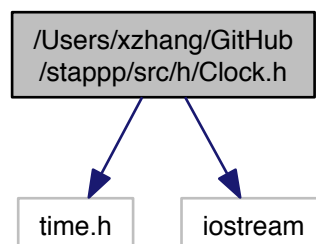
- class [CBar](#)

Bar element class.

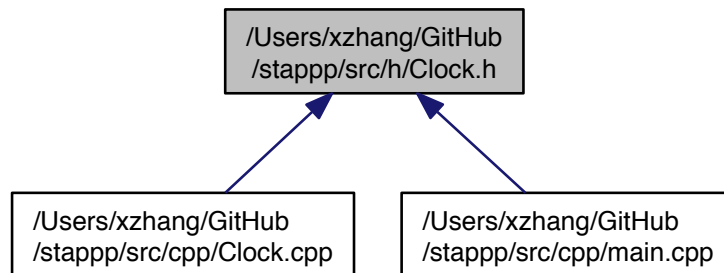
5.12 /Users/xzhang/GitHub/stapp/src/h/Clock.h File Reference

```
#include <time.h>
#include <iostream>
```

Include dependency graph for Clock.h:



This graph shows which files directly or indirectly include this file:



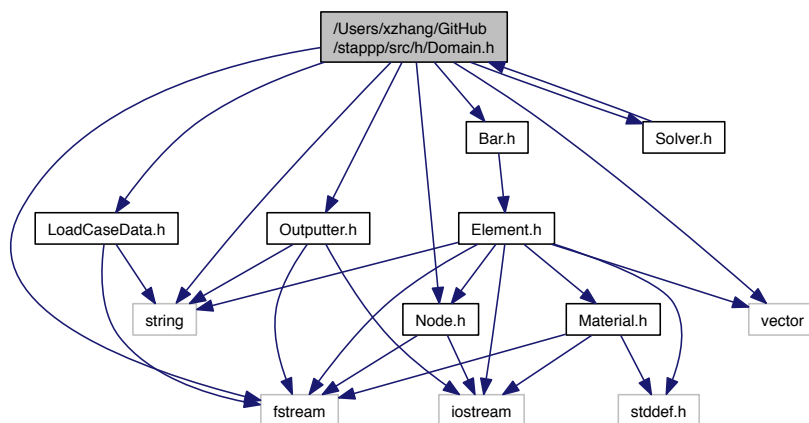
Classes

- class `Clock`
Clock class for timing.

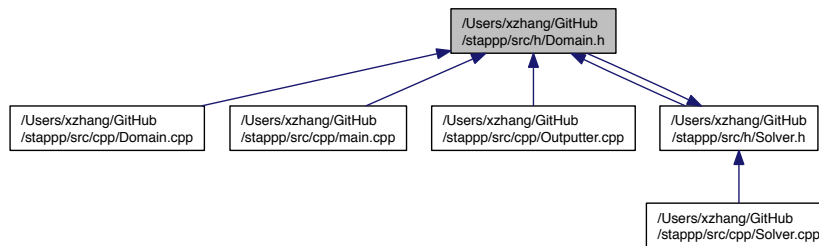
5.13 /Users/xzhang/GitHub/stapp/src/h/Domain.h File Reference

```
#include <string>
#include <fstream>
#include <vector>
#include "Node.h"
#include "Bar.h"
#include "Outputter.h"
#include "Solver.h"
#include "LoadCaseData.h"
```

Include dependency graph for Domain.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [CDomain](#)

Domain class : Define the problem domain.

Functions

- `template<class type >`
`void clear (type *a, int N)`
Clear an array.

5.13.1 Function Documentation

5.13.1.1 `clear()`

```

template<class type >
void clear (
    type * a,
    int N )
  
```

Clear an array.

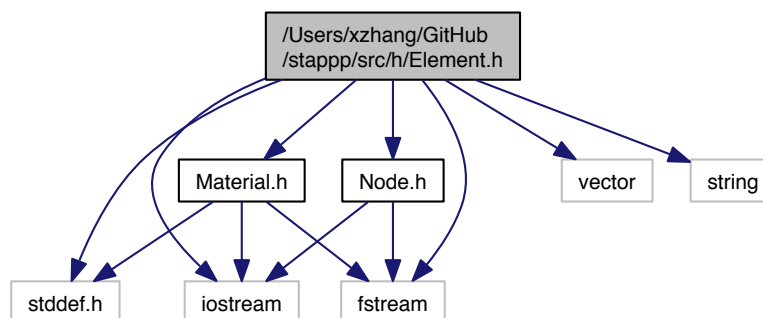
5.14 /Users/xzhang/GitHub/stapp/src/h/Element.h File Reference

```

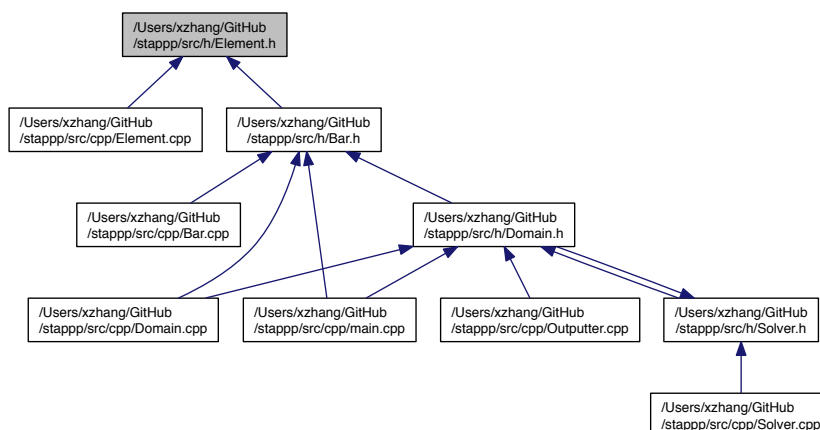
#include <stddef.h>
#include <vector>
#include <string>
#include <iostream>
#include <fstream>
#include "Node.h"
  
```

```
#include "Material.h"
```

Include dependency graph for Element.h:



This graph shows which files directly or indirectly include this file:



Classes

- class `CElement`
Element base class.

Functions

- template<class type >
void `clear` (type *a, int N)
Clear an array.

5.14.1 Function Documentation

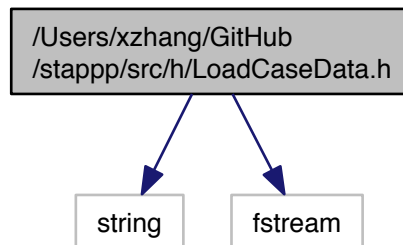
5.14.1.1 clear()

```
template<class type >
void clear (
    type * a,
    int N )
```

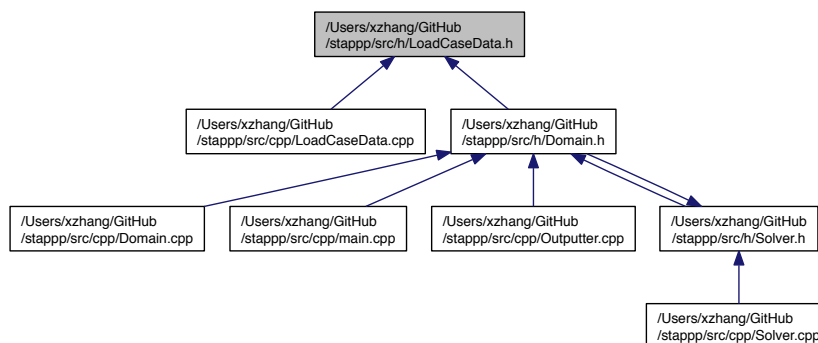
Clear an array.

5.15 /Users/xzhang/GitHub/stapp/src/h/LoadCaseData.h File Reference

```
#include <string>
#include <fstream>
Include dependency graph for LoadCaseData.h:
```



This graph shows which files directly or indirectly include this file:



Classes

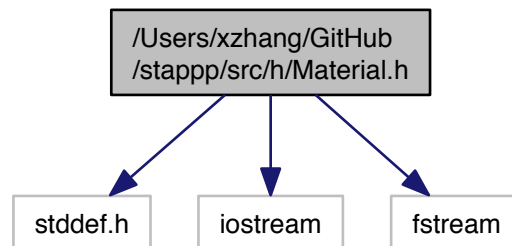
- class [CLoadCaseData](#)

Class LoadData is used to store load data.

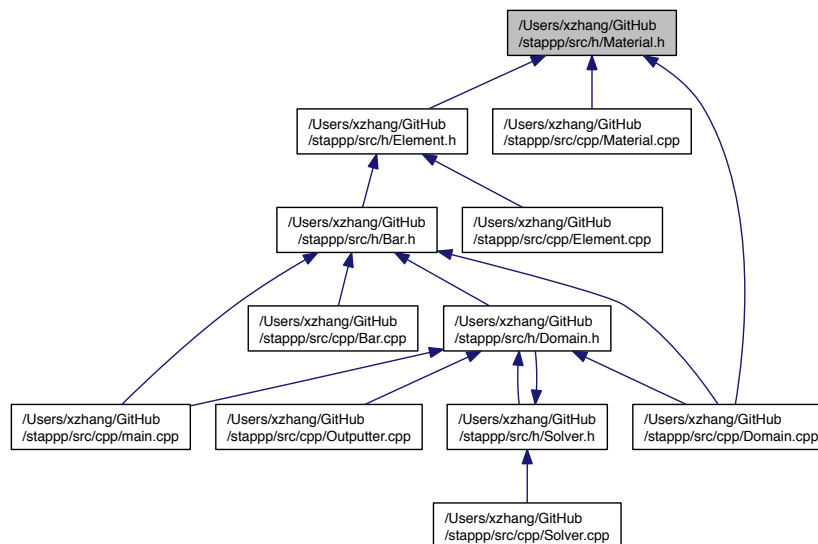
5.16 /Users/xzhang/GitHub/stapp/src/h/Material.h File Reference

```
#include <stddef.h>
#include <iostream>
#include <fstream>
```

Include dependency graph for Material.h:



This graph shows which files directly or indirectly include this file:

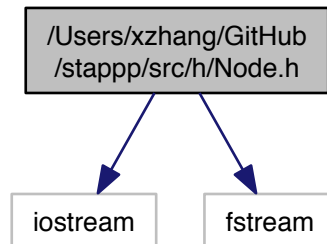


Classes

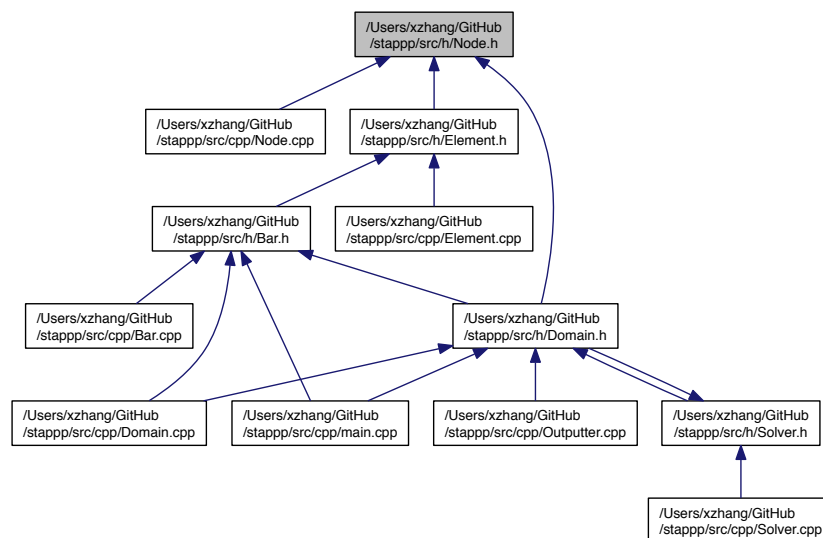
- class [CMaterial](#)
Material base class which only define one data member.
- class [CBarMaterial](#)
Material class for bar element.

5.17 /Users/xzhang/GitHub/stapp/src/h/Node.h File Reference

```
#include <iostream>
#include <fstream>
Include dependency graph for Node.h:
```



This graph shows which files directly or indirectly include this file:



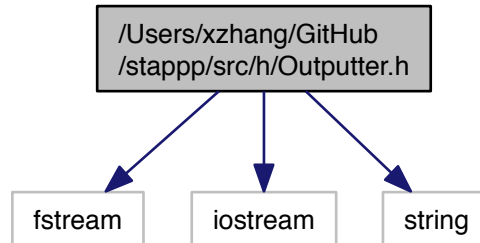
Classes

- class [CNode](#)
Node class.

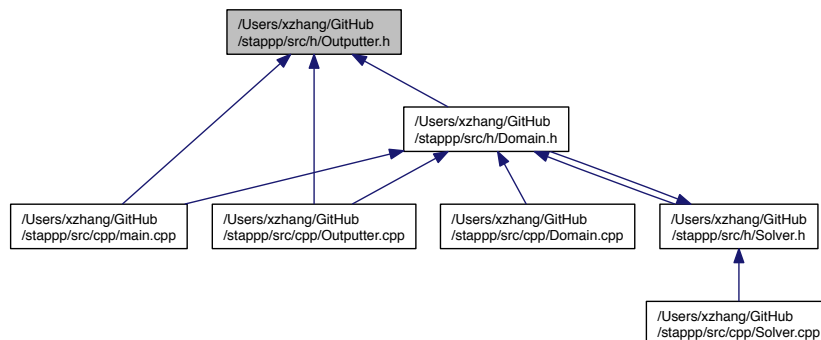
5.18 /Users/xzhang/GitHub/stapp/src/h/Outputter.h File Reference

```
#include <fstream>
#include <iostream>
#include <string>
```

Include dependency graph for Outputter.h:



This graph shows which files directly or indirectly include this file:



Classes

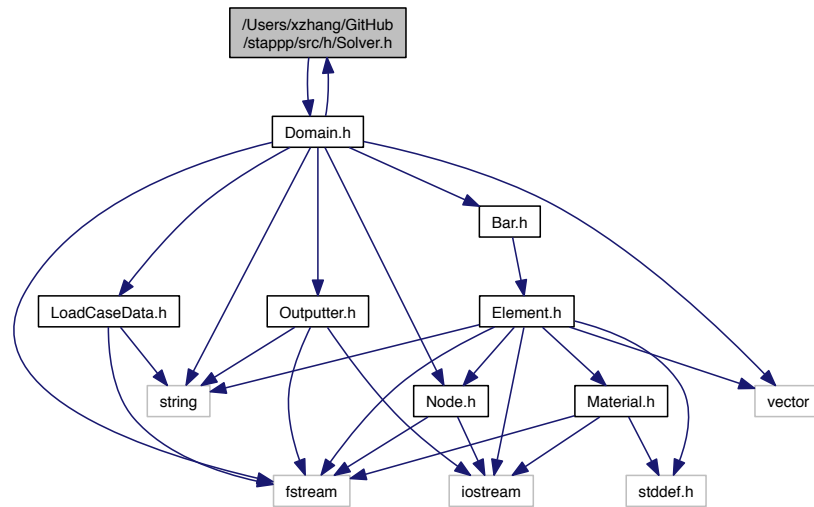
- class [COutputter](#)

Outputter class is used to output results.

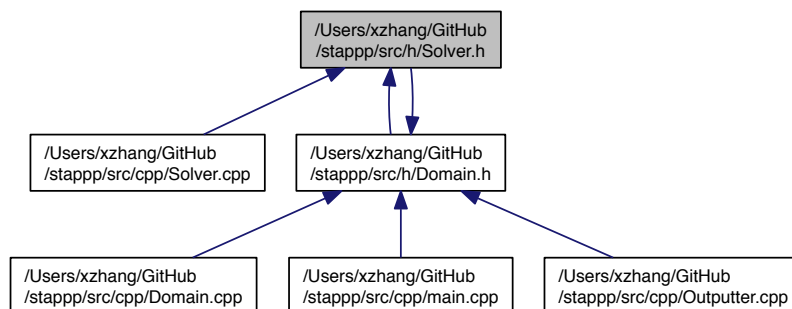
5.19 /Users/xzhang/GitHub/stapp/src/h/Solver.h File Reference

```
#include "Domain.h"
```

Include dependency graph for Solver.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [CSolver](#)
Base class for a solver.
- class [CLDLTSolver](#)
LDLT solver: A in core solver using skyline storage and column reduction scheme.

Index

[/Users/xzhang/GitHub/stappp/src/cpp/Bar.cpp](#), [51](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Clock.cpp](#), [51](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Domain.cpp](#), [52](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Element.cpp](#), [53](#)
[/Users/xzhang/GitHub/stappp/src/cpp/LoadCaseData.cpp](#), [53](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Material.cpp](#), [55](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Node.cpp](#), [55](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Outputter.cpp](#), [56](#)
[/Users/xzhang/GitHub/stappp/src/cpp/Solver.cpp](#), [57](#)
[/Users/xzhang/GitHub/stappp/src/cpp/main.cpp](#), [54](#)
[/Users/xzhang/GitHub/stappp/src/h/Bar.h](#), [57](#)
[/Users/xzhang/GitHub/stappp/src/h/Clock.h](#), [58](#)
[/Users/xzhang/GitHub/stappp/src/h/Domain.h](#), [59](#)
[/Users/xzhang/GitHub/stappp/src/h/Element.h](#), [60](#)
[/Users/xzhang/GitHub/stappp/src/h/LoadCaseData.h](#), [62](#)
[/Users/xzhang/GitHub/stappp/src/h/Material.h](#), [63](#)
[/Users/xzhang/GitHub/stappp/src/h/Node.h](#), [64](#)
[/Users/xzhang/GitHub/stappp/src/h/Outputter.h](#), [65](#)
[/Users/xzhang/GitHub/stappp/src/h/Solver.h](#), [65](#)
[_instance](#)
 [CDomain](#), [22](#)
 [COutputter](#), [47](#)
[~CBar](#)
 [CBar](#), [9](#)
[~CDomain](#)
 [CDomain](#), [16](#)
[~CLoadCaseData](#)
 [CLoadCaseData](#), [34](#)

[Allocate](#)
 [CLoadCaseData](#), [34](#)
[AllocateMatrices](#)
 [CDomain](#), [16](#)
[Area](#)
 [CBarMaterial](#), [12](#)
[AssembleForce](#)
 [CDomain](#), [16](#)
[AssembleStiffnessMatrix](#)
 [CDomain](#), [16](#)
[assembly](#)
 [CElement](#), [28](#)

[BackSubstitution](#)
 [CLDLTSolver](#), [33](#)
[bcode](#)
 [CNode](#), [42](#)

[CBar](#), [7](#)
 [~CBar](#), [9](#)
 [CBar](#), [8](#)
 [ElementStiffness](#), [9](#)
 [ElementStress](#), [9](#)
 [GenerateLocationMatrix](#), [9](#)
 [Read](#), [9](#)
 [SizeOfStiffnessMatrix](#), [10](#)
 [Write](#), [10](#)
[CBarMaterial](#), [11](#)
 [Area](#), [12](#)
 [Read](#), [12](#)
 [Write](#), [12](#)
[CDomain](#), [13](#)
 [_instance](#), [22](#)
 [~CDomain](#), [16](#)
 [AllocateMatrices](#), [16](#)
 [AssembleForce](#), [16](#)
 [AssembleStiffnessMatrix](#), [16](#)
 [CDomain](#), [16](#)
 [CElement](#), [30](#)
 [CalculateColumnHeights](#), [17](#)
 [CalculateDiagnoalAddress](#), [17](#)
 [CalculateEquationNumber](#), [17](#)
 [ColumnHeights](#), [22](#)
 [DiagonalAddress](#), [22](#)
 [ElementSetList](#), [22](#)
 [ElementTypes](#), [22](#)
 [Force](#), [23](#)
 [GetColumnHeights](#), [17](#)
 [GetDiagonalAddress](#), [17](#)
 [GetDisplacement](#), [17](#)
 [GetElementSetList](#), [18](#)
 [GetElementTypes](#), [18](#)
 [GetForce](#), [18](#)
 [GetLoadCases](#), [18](#)
 [GetMODEX](#), [19](#)
 [GetMaterialSetList](#), [18](#)
 [GetMK](#), [18](#)
 [GetNEQ](#), [19](#)
 [GetNLCASE](#), [19](#)
 [GetNLOAD](#), [19](#)
 [GetNUMEG](#), [20](#)
 [GetNUMMAT](#), [20](#)
 [GetNUMNP](#), [20](#)
 [GetNUME](#), [19](#)
 [GetNWK](#), [20](#)
 [GetNodeList](#), [19](#)
 [GetStiffnessMatrix](#), [20](#)
 [GetTitle](#), [20](#)

- Input, [23](#)
- Instance, [21](#)
- LoadCases, [23](#)
- MODEX, [23](#)
- MaterialSetList, [23](#)
- MK, [23](#)
- NEQ, [24](#)
- NLCASE, [24](#)
- NLOAD, [24](#)
- NUMEG, [24](#)
- NUMMAT, [25](#)
- NUMNP, [25](#)
- NUME, [24](#)
- NWK, [25](#)
- NodeList, [24](#)
- ReadBarElementData, [21](#)
- ReadData, [21](#)
- ReadElements, [21](#)
- ReadLoadCases, [21](#)
- ReadNodalPoints, [21](#)
- StiffnessMatrix, [25](#)
- Title, [25](#)
- CElement, [26](#)
 - assembly, [28](#)
 - CDomain, [30](#)
 - CElement, [27](#)
 - CalculateColumnHeight, [28](#)
 - ElementMaterial, [30](#)
 - ElementStiffness, [28](#)
 - ElementStress, [28](#)
 - GenerateLocationMatrix, [28](#)
 - GetElementMaterial, [29](#)
 - GetNodes, [29](#)
 - LocationMatrix, [30](#)
 - NEN, [30](#)
 - ND, [30](#)
 - nodes, [31](#)
 - Read, [29](#)
 - SizeOfStiffnessMatrix, [29](#)
 - Write, [29](#)
- CLDLTSolver, [31](#)
 - BackSubstitution, [33](#)
 - CLDLTSolver, [32](#)
 - LDLT, [33](#)
 - Solve, [33](#)
- CLoadCaseData, [33](#)
 - ~CLoadCaseData, [34](#)
 - Allocate, [34](#)
 - CLoadCaseData, [34](#)
 - dof, [35](#)
 - load, [35](#)
 - nloads, [35](#)
 - node, [36](#)
 - Read, [35](#)
 - Write, [35](#)
- CMaterial, [39](#)
 - E, [40](#)
 - nset, [40](#)
 - Read, [40](#)
 - Write, [40](#)
- CNode, [41](#)
 - bcode, [42](#)
 - CNode, [41](#)
 - NDF, [43](#)
 - NodeNumber, [43](#)
 - Read, [42](#)
 - Write, [42](#)
 - WriteEquationNo, [42](#)
 - WriteNodalDisplacement, [42](#)
 - XYZ, [43](#)
- COutputter, [43](#)
 - _instance, [47](#)
 - COutputter, [45](#)
 - GetOutputFile, [45](#)
 - Instance, [45](#)
 - OutputElementInfo, [45](#)
 - OutputElementStress, [45](#)
 - OutputEquationNumber, [45](#)
 - OutputFile, [47](#)
 - OutputHeading, [46](#)
 - OutputLoadInfo, [46](#)
 - OutputNodalDisplacement, [46](#)
 - OutputNodeInfo, [46](#)
 - OutputTotalSystemData, [46](#)
 - PrintBarElementData, [46](#)
 - PrintTime, [47](#)
- CSolver, [48](#)
 - CSolver, [49](#)
 - FEMData, [49](#)
 - Solve, [49](#)
- CalculateColumnHeight
 - CElement, [28](#)
- CalculateColumnHeights
 - CDomain, [17](#)
- CalculateDiagnoalAddress
 - CDomain, [17](#)
- CalculateEquationNumber
 - CDomain, [17](#)
- Clear
 - Clock, [37](#)
- clear
 - Domain.cpp, [53](#)
 - Domain.h, [60](#)
 - Element.h, [61](#)
- Clock, [36](#)
 - Clear, [37](#)
 - Clock, [37](#)
 - ct_, [38](#)
 - ElapsedTime, [37](#)
 - Resume, [37](#)
 - st0_, [38](#)
 - st1_, [38](#)
 - Start, [37](#)
 - Stop, [38](#)
 - t0_, [38](#)
 - t1_, [38](#)

- ColumnHeights
 - CDomain, 22
- ct_
 - Clock, 38
- DiagonalAddress
 - CDomain, 22
- dof
 - CLoadCaseData, 35
- Domain.cpp
 - clear, 53
- Domain.h
 - clear, 60
- E
 - CMaterial, 40
- ElapsedTime
 - Clock, 37
- Element.h
 - clear, 61
- ElementMaterial
 - CElement, 30
- ElementSetList
 - CDomain, 22
- ElementStiffness
 - CBar, 9
 - CElement, 28
- ElementStress
 - CBar, 9
 - CElement, 28
- ElementTypes
 - CDomain, 22
- FEMData
 - CSolver, 49
- Force
 - CDomain, 23
- GenerateLocationMatrix
 - CBar, 9
 - CElement, 28
- GetColumnHeights
 - CDomain, 17
- GetDiagonalAddress
 - CDomain, 17
- GetDisplacement
 - CDomain, 17
- GetElementMaterial
 - CElement, 29
- GetElementSetList
 - CDomain, 18
- GetElementTypes
 - CDomain, 18
- GetForce
 - CDomain, 18
- GetLoadCases
 - CDomain, 18
- GetMODEX
 - CDomain, 19
- GetMaterialSetList
 - CDomain, 18
- GetMK
 - CDomain, 18
- GetNEQ
 - CDomain, 19
- GetNLCASE
 - CDomain, 19
- GetNLOAD
 - CDomain, 19
- GetNUMEG
 - CDomain, 20
- GetNUMMAT
 - CDomain, 20
- GetNUMNP
 - CDomain, 20
- GetNUME
 - CDomain, 19
- GetNWK
 - CDomain, 20
- GetNodeList
 - CDomain, 19
- GetNodes
 - CElement, 29
- GetOutputFile
 - COutputter, 45
- GetStiffnessMatrix
 - CDomain, 20
- GetTitle
 - CDomain, 20
- Input
 - CDomain, 23
- Instance
 - CDomain, 21
 - COutputter, 45
- LDLT
 - CLDLTSolver, 33
- load
 - CLoadCaseData, 35
- LoadCases
 - CDomain, 23
- LocationMatrix
 - CElement, 30
- MODEX
 - CDomain, 23
- main
 - main.cpp, 55
- main.cpp
 - main, 55
- MaterialSetList
 - CDomain, 23
- MK
 - CDomain, 23
- NDF
 - CNode, 43

- NEN
 - CElement, [30](#)
- NEQ
 - CDomain, [24](#)
- NLCASE
 - CDomain, [24](#)
- NLOAD
 - CDomain, [24](#)
- NUMEG
 - CDomain, [24](#)
- NUMMAT
 - CDomain, [25](#)
- NUMNP
 - CDomain, [25](#)
- NUME
 - CDomain, [24](#)
- NWK
 - CDomain, [25](#)
- ND
 - CElement, [30](#)
- nloads
 - CLoadCaseData, [35](#)
- node
 - CLoadCaseData, [36](#)
- NodeList
 - CDomain, [24](#)
- NodeNumber
 - CNode, [43](#)
- nodes
 - CElement, [31](#)
- nset
 - CMaterial, [40](#)
- OutputElementInfo
 - COutputter, [45](#)
- OutputElementStress
 - COutputter, [45](#)
- OutputEquationNumber
 - COutputter, [45](#)
- OutputFile
 - COutputter, [47](#)
- OutputHeading
 - COutputter, [46](#)
- OutputLoadInfo
 - COutputter, [46](#)
- OutputNodalDisplacement
 - COutputter, [46](#)
- OutputNodeInfo
 - COutputter, [46](#)
- OutputTotalSystemData
 - COutputter, [46](#)
- PrintBarElementData
 - COutputter, [46](#)
- PrintTime
 - COutputter, [47](#)
- Read
 - CBar, [9](#)
- CBarMaterial, [12](#)
 - CElement, [29](#)
 - CLoadCaseData, [35](#)
 - CMaterial, [40](#)
 - CNode, [42](#)
- ReadBarElementData
 - CDomain, [21](#)
- ReadData
 - CDomain, [21](#)
- ReadElements
 - CDomain, [21](#)
- ReadLoadCases
 - CDomain, [21](#)
- ReadNodalPoints
 - CDomain, [21](#)
- Resume
 - Clock, [37](#)
- SizeOfStiffnessMatrix
 - CBar, [10](#)
 - CElement, [29](#)
- Solve
 - CLDLTSolver, [33](#)
 - CSolver, [49](#)
- st0_
 - Clock, [38](#)
- st1_
 - Clock, [38](#)
- Start
 - Clock, [37](#)
- StiffnessMatrix
 - CDomain, [25](#)
- Stop
 - Clock, [38](#)
- t0_
 - Clock, [38](#)
- t1_
 - Clock, [38](#)
- Title
 - CDomain, [25](#)
- Write
 - CBar, [10](#)
 - CBarMaterial, [12](#)
 - CElement, [29](#)
 - CLoadCaseData, [35](#)
 - CMaterial, [40](#)
 - CNode, [42](#)
- WriteEquationNo
 - CNode, [42](#)
- WriteNodalDisplacement
 - CNode, [42](#)
- XYZ
 - CNode, [43](#)