CADMAS - STR Coupled Analysis Section Program Description

This section describes the variables and subroutines that were added to CADMAS in order to add coupled analysis functions with STR.

1. Explanation of Variables

［1］Global variables by common

File name：SF_STRUCT.h

Common block name：SF_STRUCT

Variable name	Type	Contents
ICPL	I4	Coupled flag with structural analysis =0: uncoupled =1: one-way coupling =2: bidirectional coupling
IPART	I4	Retention range of structural mesh data when coupled with structural analysis =0: Holds all mesh data of the structure for each process =1: For each process, only the mesh data of structures that may interfere with its own area is retained.
IGEO	I4	Presence or absence of geomaterials in the structure model when coupled with structural analysis =0: no ground =1: There is a ground
IOT	I4	Time series file output flag (used to output data.prs when coupled in one direction) =0: No output =1: Output
IENS	I4	File output flag for EnSight
INT4	I4	unused
NELM	I4	Number of structure mesh elements retained per process
NELM0	I4	Total number of elements in the structure mesh
NNOD	I4	Number of structure mesh nodes retained per process
NNOD0	I4	Total number of nodes in the structure mesh
NPFC	I4	Number of structure mesh surface elements retained per process
NPFC0	I4	Number of all surface elements in the structure mesh
TSTR1	R8	In bidirectional coupling, the time corresponding to the results received from the structural analysis program (the results from these two times are linearly interpolated and used in CADMAS)
TSTR2	R8	
IROOTS	I4	Rank in MPI_COMM_WORLD of the representative process in the structural analysis program that communicates with CADMAS during bidirectional coupling.
ICON	I4	Whether or not the contact analysis function is used in the structural analysis when bidirectional coupling is used =0: No contact =1: With contact
NICRG	I4	Number of contact bodies

NCTR	I4	Number of contact surface elements (in the case of a quadrilateral, divided into triangles)
E_MEAN	R8	Average contact surface size
NRST	I4	Total number of restart file output steps when bidirectional coupled
IRST	I4	Step number to start restart calculation when bidirectional coupled
IROUT	I4	Output step number of restart file when bi-directional coupled
IOR	I4	Restart file output flag for one-way coupled
PLOWER2	R8	Lower limit of GGV (porosity) in cells sandwiched between obstacle cells
GMIN	R8	Upper limit of GGX, GGY, GGZ (cell interface porosity) to set FMIN
FMIN	R8	Lower limit of FX, FY, FZ (VOF function value of cell interface)

［２］ Global Variables by Module

File name: vf_a2array.f90

Module name: VF_A2ARRAY (additional variable)

Variable name	Type	Contents
DGGV(NUMI,NUMJ,NUMK)	R8	Porosity change (per sub-loop)
DGLV(NUMI,NUMJ,NUMK)	R8	Change in λ_v (per sub-loop)
GGV_0(NUMI,NUMJ,NUMK)	R8	Porosity (initial value)
GGX_0(NUMI,NUMJ,NUMK)	R8	Area transmittance in X direction (initial value)
GGY_0(NUMI,NUMJ,NUMK)	R8	Area transmittance in Y direction (initial value)
GGZ_0(NUMI,NUMJ,NUMK)	R8	Area transmittance in Z direction (initial value)
BCT0－INDBC0	－	Initial value of BCT-INDBC

File name: sf_array.f90

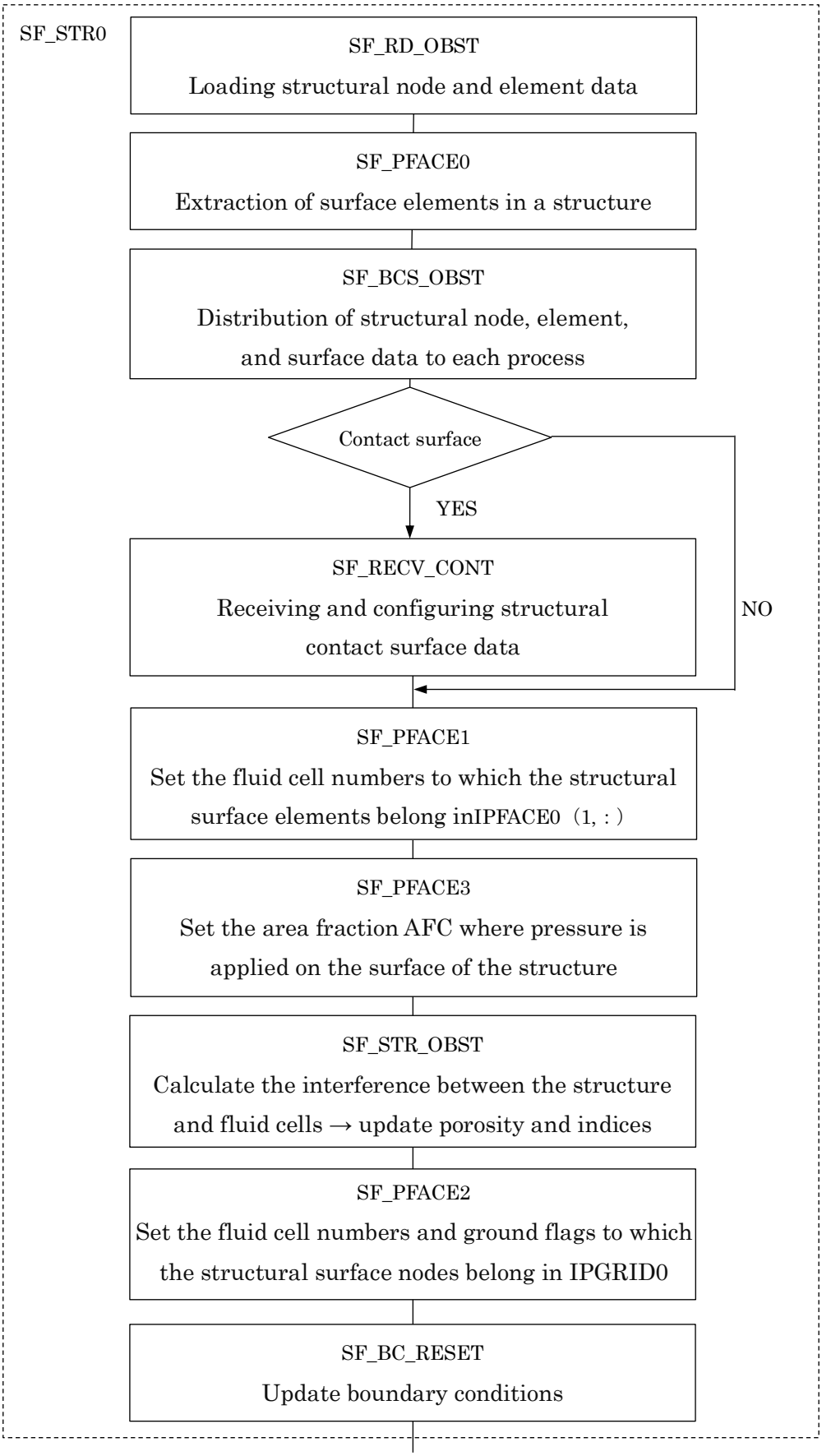
Module name: SF_ARRAY

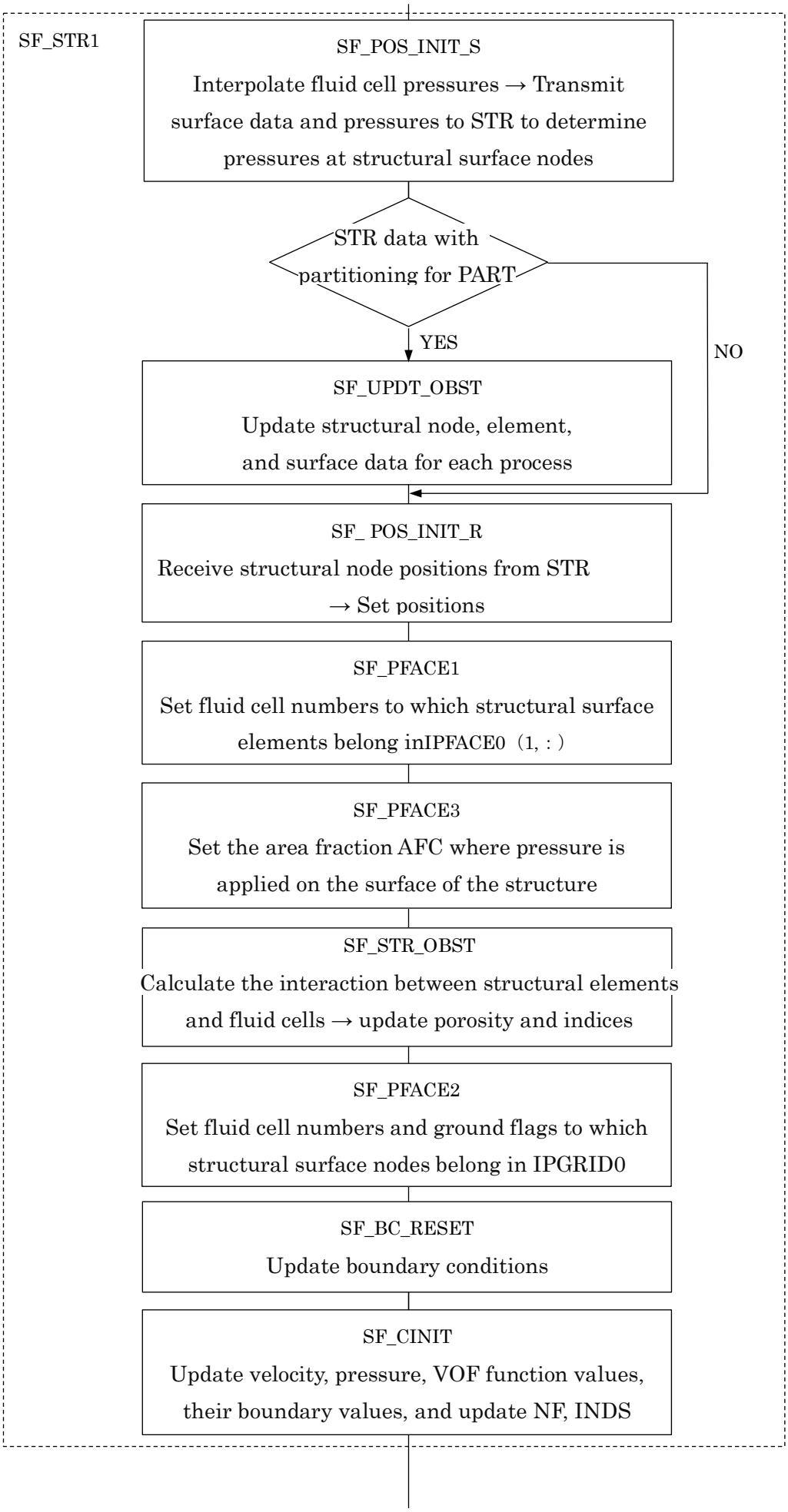
Variable name	Type	Contents
IELM(23,NELM)	I4	Structure Element Data (1,I):Element number (2,I):Element type =0: General structure =1: Ground =2: Stone (3,I): Number of Constituent Nodes (4:23,I): configuration node number
POR(NELM)	R8	Porosity (stone material)
IENO(NELM)	I4	Element number correspondence table (each process → whole)
GRID(3,NNOD)	R8	structure node coordinates
INDG(NNOD)	I4	structure node number
IGNO(NNOD)	I4	Node number correspondence table (each process → whole)
IPFACE(11,NPFC)	I4	Structure surface data (per process) (1,I): Cell number to which the center of gravity of the surface belongs (2,I): Element type to which the surface belongs =0: General Structures =1: ground =2: stone (3,I): Number of Constituent Nodes (4:11,I): configuration node number
IPFACE0(11,NPFC0)	I4	Structure surface data (all processes)
IPFNO(NPFC)	I4	Surface number correspondence table (each process → total)
AFC(NPFC0)	R8	Percentage of area subjected to pressure on the surface of the structure

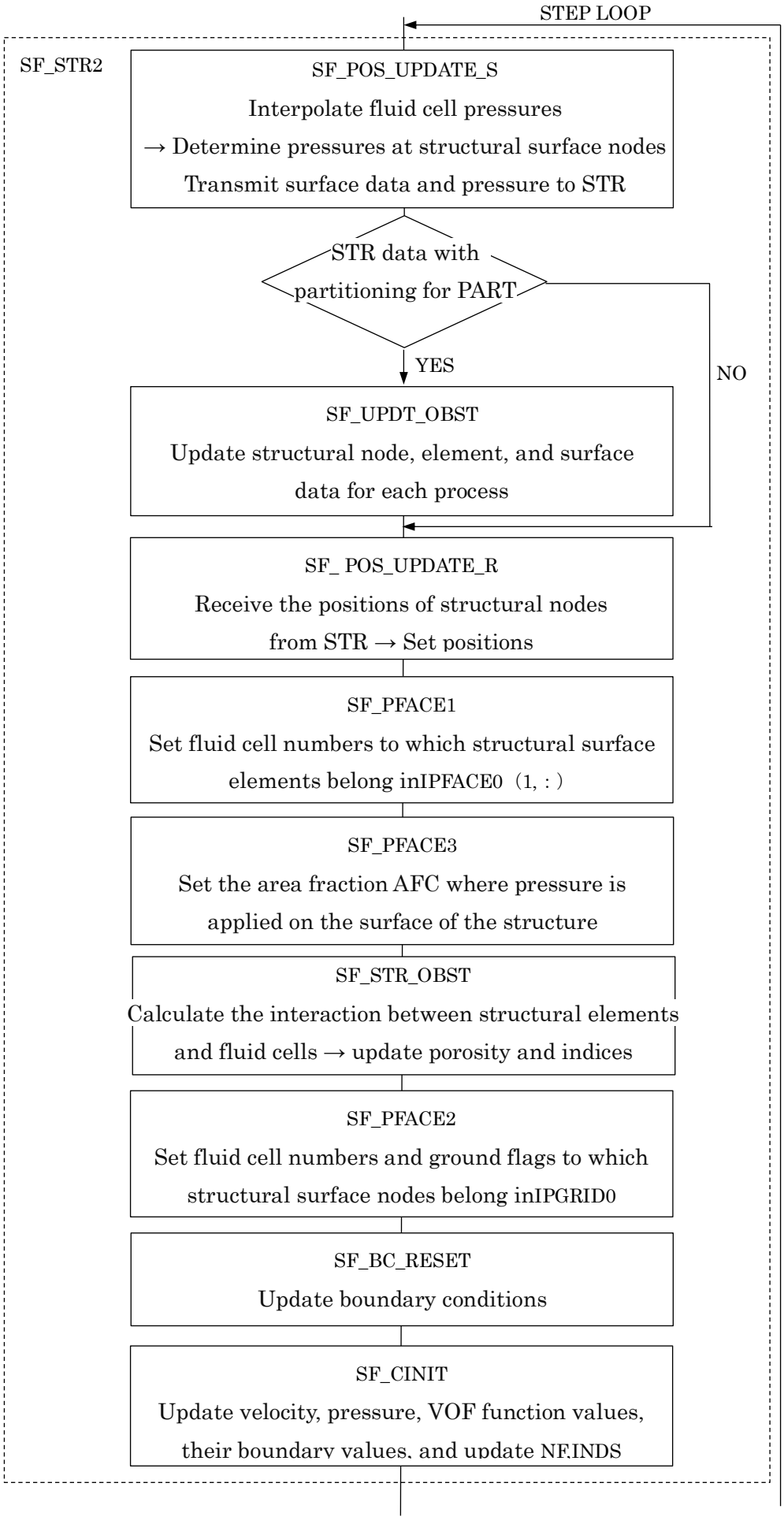
IPGRID(2,NNOD)	I4	Structure surface nodal data (per process) (1,I): Cell number to which the node belongs (2,I): Element type to which the node belongs =0: Other than ground =1: ground
IPGRID0(2,NNOD0)	I4	Structure surface nodal data (all processes)
IPND0(NNOD0)	I4	Structure surface nodal pressure flag =0: No pressure value =1: Pressure value available
PRES(NNOD)	R8	Structure surface nodal pressure (per process)
PRES0(NNOD0)	R8	Structure surface nodal pressure (all processes)
ICRG(NICRG)	I4	Contact surface end address of each contact body
ICTR(4,NCTR)	I4	Contact surface data (1,I):IPFACE number to which the contact surface belongs (2:4,I):Configuration node number
ICTB(NICRG,NICRG)	I4	Combination of contact body
POS(3,NNOD)	R8	Structure node position coordinates (per process)
POS1(3,NNOD)	R8	Structure nodal point position coordinates (time: TSTR1) (per process)
POS2(3,NNOD)	R8	Structure nodal point position coordinates (time: TSTR2) (per process)
POS0(3,NNOD0)	R8	Structure node position coordinates (all processes)
POS10(3,NNOD0)	R8	Structure node position coordinates (time:TSTR1)(all processes)
POS20(3,NNOD0)	R8	Structure node position coordinates (time:TSTR2)(all processes)
DVEL(3,NELM)	R8	Dulcie flow velocity of the ground
DVEL1(3,NELM)	R8	Dulcie flow velocity at ground (time: TSTR1) (per process)
DVEL2(3,NELM)	R8	Dulcie flow velocity at ground (time: TSTR2) (per process)
DVEL10(3,NELM0)	R8	Dulcie flow velocity at ground (time:TSTR1)(all processes)
DVEL20(3,NELM0)	R8	Dulcie flow velocity at ground (time:TSTR2)(all processes)

2．Processing Flow

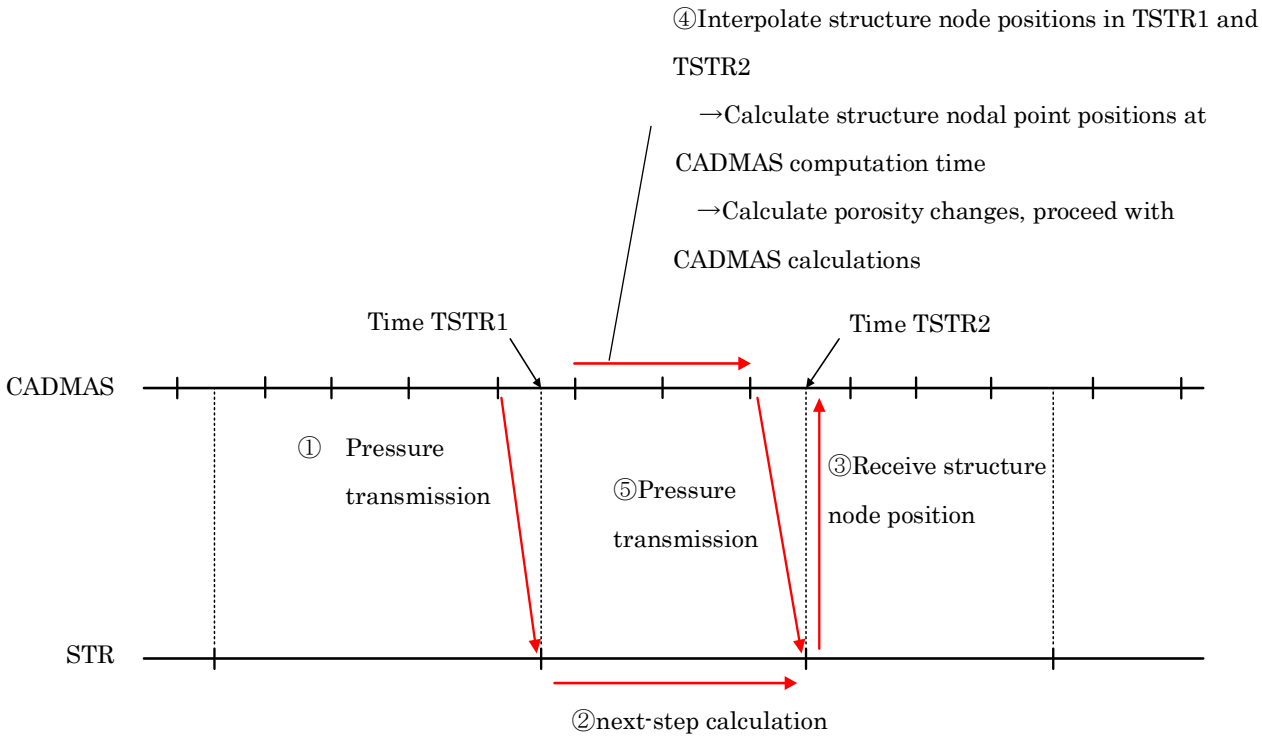
［1］Overall flow of the coupled analysis section with STR (showing the case of bidirectional coupling)




SF_STR1
SF_POS_INIT_S
Interpolate fluid cell pressures → Transmit surface data and pressures to STR to determine pressures at structural surface nodes
STR data with partitioning for PART
YES
NO
SF_UPDT_OBST
Update structural node, element, and surface data for each process
SF_ POS_INIT_R
Receive structural node positions from STR → Set positions
SF_PFACE1
Set fluid cell numbers to which structural surface elements belong inIPFACE0（1, : ）
SF_PFACE3
Set the area fraction AFC where pressure is applied on the surface of the structure
SF_STR_OBST
Calculate the interaction between structural elements and fluid cells → update porosity and indices
SF_PFACE2
Set fluid cell numbers and ground flags to which structural surface nodes belong in IPGRID0
SF_BC_RESET
Update boundary conditions
SF_CINIT
Update velocity, pressure, VOF function values, their boundary values, and update NF, INDS


STEP LOOP
SF_STR2
SF_POS_UPDATE_S
Interpolate fluid cell pressures
→ Determine pressures at structural surface nodes
Transmit surface data and pressure to STR
STR data with
partitioning for PART
YES
NO
SF_UPDT_OBST
Update structural node, element, and surface
data for each process
SF_ POS_UPDATE_R
Receive the positions of structural nodes
from STR → Set positions
SF_PFACE1
Set fluid cell numbers to which structural surface
elements belong inIPFACE0（1, : ）
SF_PFACE3
Set the area fraction AFC where pressure is
applied on the surface of the structure
SF_STR_OBST
Calculate the interaction between structural elements
and fluid cells → update porosity and indices
SF_PFACE2
Set fluid cell numbers and ground flags to which
structural surface nodes belong inIPGRID0
SF_BC_RESET
Update boundary conditions
SF_CINIT
Update velocity, pressure, VOF function values,
their boundary values, and update NFLAGS

［２］ Timing of data reception and transmission with STR



［３］ Porosity Calculation Method

（１） cell porosity

The porosity of the fluid cell at each calculation step time is obtained by calculating the volume of interference between the structure element and the fluid cell at that time. The procedure for obtaining the interference volume is shown below.

① Divide the structure elements into tetras.

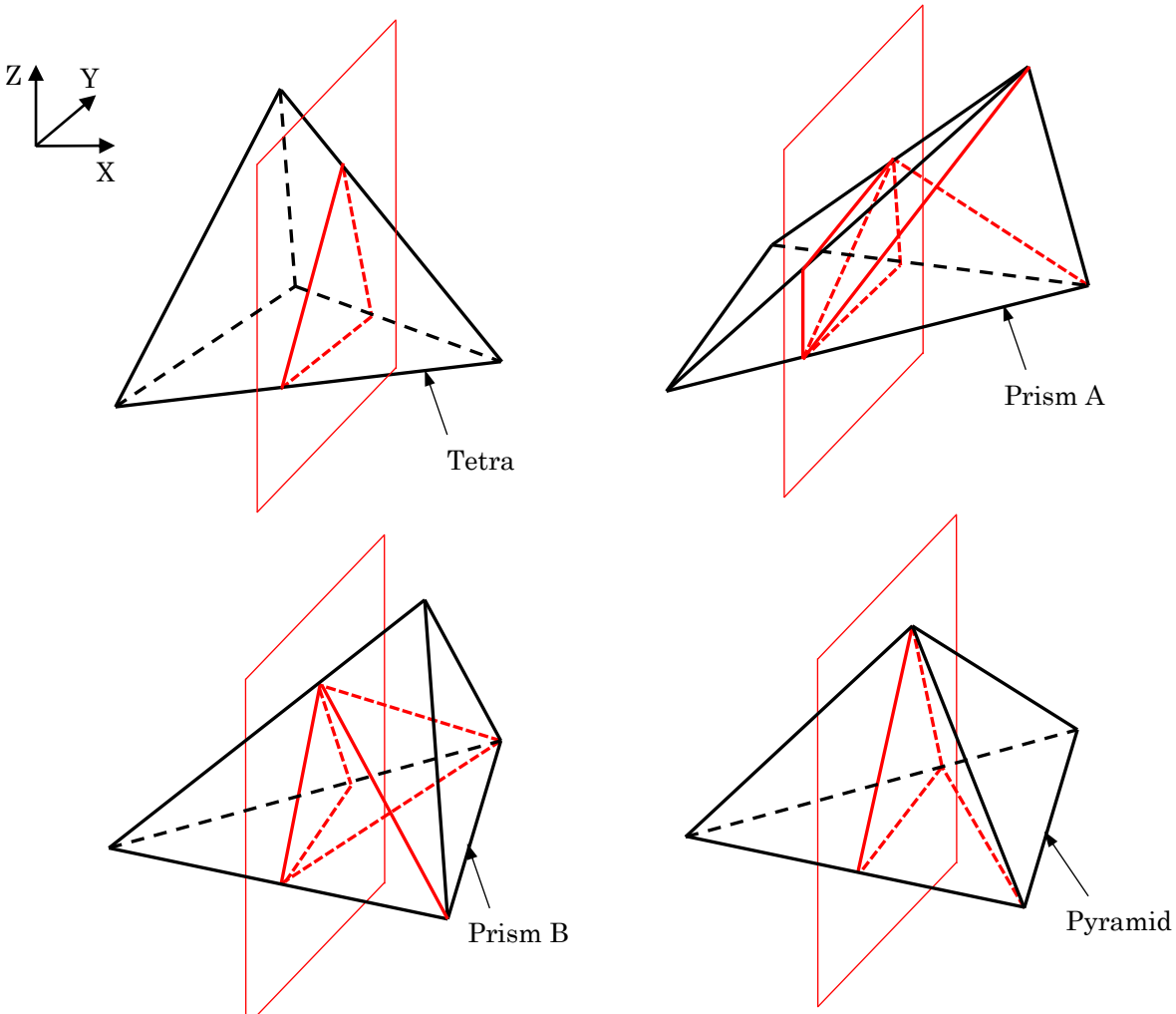
② The interference volume between each tetrahedron and the fluid cell is calculated and summed. The interference volume between each tetrahedron and fluid cell is obtained by the following procedure.

③ Before we begin, let us define the six surfaces that make up the fluid cell as follows.

X(-) plane: Plane perpendicular to the X axis, X axis (-) side
X(+) plane: Plane perpendicular to the X axis, X axis (+) side
Y(-) plane: Plane perpendicular to the Y-axis, Y-axis (-) side
Y(+) plane: Plane perpendicular to the Y-axis, Y-axis (+) side
Z(-) plane: Plane perpendicular to the Z-axis, Z-axis (-) side
Z(+) plane: Plane perpendicular to the Z-axis, Z-axis (+) side

④ First, the tetra is cut in the X(-) plane, leaving the cell side (i.e., the X-axis + side, the right side in the figure below).

⑤ The portion remaining on the cell side after being cut in ④ is classified into four patterns as shown in the figure below. Then, each of them is divided into tetras (those that are already tetra-shaped need not be divided).



⑥ Cut the tetra formed by ⑤ at the X(+) plane of the fluid cell, and divide the remaining part on the cell side into tetras in the same manner as ⑤.

⑦ The same process is performed for the Y and Z planes. This yields the total volume of tetrahedra remaining inside the cell after being cut on the six faces of the fluid cell.

（2） Cell interface porosity

The porosity of the fluid cell interface is determined by calculating the interference area between the triangular surface and the cell interface using the intersection of the tetrahedron and the cut surface created in (1)(⑤). The procedure for obtaining the interference area is shown below.

① Before doing so, set the X and Y axes along the edges of the fluid interface (rectangle), and define the four edges that make up the interface as follows.

X(-)辺：Edge perpendicular to the x-axis, X -axis (-) side

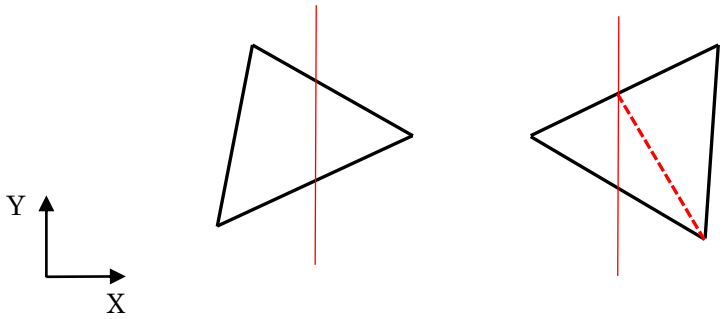
X(+)辺：Edge perpendicular to the x-axis, X -axis (+) side

Y(-)辺：Edge perpendicular to the Y-axis, Y-axis (-) side

Y(+)辺：Edge perpendicular to Y-axis, Y-axis (+) side

② First, the triangles are cut at the X(-) edge, leaving the cell interface side (i.e., the X-axis + side, the right side in the figure below).

③ The part cut off at ② and remaining on the cell side is classified into two patterns of shapes as shown in the figure below: a quadrilateral is divided into two triangles; a quadrilateral is divided into two triangles.



④ Cut the triangle formed by ③ at the X(+) edge of the cell interface, and process the remaining part on the cell side in the same way as ③.

⑤ The same process is performed for the Y edge. This gives the total area of the triangles remaining inside the cell after being cut on the four sides of the cell interface.

3. Subroutine Description

Routine-name	SF_RD_OBST		
Function	Structural node and element data loading		
Argument reference module	SF_ARRAY		
Argument name	Type	I/O	Contents
IELM(23,NELM)	I4	O	Structural Element Data
POR(NELM)	R8	O	Porosity (stone material)
GRID(3,NNOD)	R8	O	structure node coordinates
INDG(NNOD)	I4	O	structure node number
POS0(3,NNOD0)	R8	O	Structure node position coordinates (all processes)

Routine-name	SF_PFACE0		
Function	Structural Surface Element Extraction		
Argument reference module	SF_ARRAY		
Argument name	Type	I/O	Contents
IELM(23,NELM)	I4	I	Structural Element Data
IPFACE(11,NPFC)	I4	O	Structure surface data (per process)
IPFACE0(11,NPFC0)	I4	O	Structure surface data (all processes)
AFC(NPFC0)	R8	O	(ALLOCATE only) Percentage of area subjected to pressure on the surface of the structure
IPGRID0(2,NNOD0)	I4	O	(ALLOCATE only) Structure surface nodal data (all processes)
IPND0(NNOD0)	I4	O	(ALLOCATE only) Structure surface nodal pressure flag
PRES0(NNOD0)	R8	O	(ALLOCATE only) Structure surface nodal pressure (all processes)

Routine-name	SF_BCS_OBST, SF_ARRAY		
Function	Distribute structural nodal, element, and surface data to each process		
Argument reference module	VF_A2ARRAY		
Argument name	Type	I/O	Contents
IELM(23,NELM)	I4	I/O	Structural Element Data
POR(NELM)	R8	I/O	Porosity (stone material)
IENO(NELM)	I4	O	Element number correspondence table (each process → whole)
GRID(3,NNOD)	R8	I/O	structure node coordinates
INDG(NNOD)	I4	I/O	structure node number
IGNO(NNOD)	I4	O	Node number correspondence table (each process → whole)
IPFACE(11,NPFC)	I4	I/O	Structure surface data (per process)
IPFNO(NPFC)	I4	O	Surface number correspondence table (each process -> total)

IPGRID(2,NNOD)	I4	O	(ALLOCATE only) Structure surface nodal data (per process)
PRES(NNOD)	R8	O	(ALLOCATE only) Structure surface nodal pressure (per process)
POS(3,NNOD)	R8	O	Structure node position coordinates (per process)
POS1(3,NNOD)	R8	O	(ALLOCATE only) Structure nodal point position coordinates (time: TSTR1) (per process)
POS2(3,NNOD)	R8	O	(ALLOCATE only) Structure nodal point position coordinates (time:TSTR2)(per process)
DVEL(3,NELM)	R8	O	Dulcie flow velocity of the ground
DVEL1(3,NELM)	R8	O	(ALLOCATE only) Dulcie flow velocity in ground (time:TSTR1)(per process)
DVEL2(3,NELM)	R8	O	(ALLOCATE ONLY) Dulcie flow velocity in ground (time:TSTR2)(per process)
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc.
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc.
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc.

Routine-name	SF_RECV_CONT		
Function	Receive and set structure contact surface data		
Argument reference module	SF_ARRAY		
Argument name	Type	I/O	Contents
IPFACE0(11,NPFC0)	I4	I	Structure surface data (all processes)
ICRG(NICRG)	I4	O	Contact surface end address of each contact body
ICTR(4,NCTR)	I4	O	contact surface data
ICTB(NICRG,NICRG)	I4	O	Combination of contact body
POS0(3,NNOD0)	R8	I	Structure node position coordinates (all processes)

Routine-name	SF_PFACE1		
Function	Set the fluid cell number to which the structure surface element belongs to IPFACE0(1,:)		
Argument reference module	VF_A2ARRAY, SF_ARRAY		
Argument name	Type	I/O	Contents
IPFACE(11,NPFC)	I4	I/O	Structure surface data (per process)
IPFACE0(11,NPFC0)	I4	I/O	Structure surface data (all processes)
IPFNO(NPFC)	I4	I	Surface number correspondence table (each process → total)
POS(3,NNOD)	R8	I	Structure node position coordinates (per process)
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc.
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc.
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc.
INDB0(MAXB1,NUMB0)	I4	I	Boundary surface index (initial value)

Routine-name	SF_PFACE3		
Function	Percentage of area subject to pressure on the surface of the structure AFC set		
Argument reference module	SF_ARRAY		
Argument name	Type	I/O	Contents
IPFACE0(11,NPFC0)	I4	I	Structure surface data (all processes)
AFC(NPFC0)	R8	O	Percentage of area subjected to pressure on the surface of the structure
ICRG(NICRG)	I4	I	Contact surface end address of each contact body
ICTR(4,NCTR)	I4	I	contact surface data
ICTB(NICRG,NICRG)	I4	I	Combination of contact body
POS0(3,NNOD0)	R8	I	Structure node position coordinates (all processes)

Routine-name	SF_STR_OBST		
Function	Calculate interference between structure and fluid cells → Update porosity, index		
Argument reference module	Type	I/O	Contents
GGV(NUMI,NUMJ,NUMK)	R8	O	porosity
GGX(NUMI,NUMJ,NUMK)	R8	O	X-direction area through rate
GGY(NUMI,NUMJ,NUMK)	R8	O	Y-direction area through rate
GGZ(NUMI,NUMJ,NUMK)	R8	O	Z-direction area through rate
GLV(NUMI,NUMJ,NUMK)	R8	O	λ_v
GLX(NUMI,NUMJ,NUMK)	R8	O	λ_x
GLY(NUMI,NUMJ,NUMK)	R8	O	λ_y
GLZ(NUMI,NUMJ,NUMK)	R8	O	λ_z
NF(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating cell status
INDC(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating the calculation status of the cell
INDX(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating the state of the X-plane
INDY(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating the state of the Y-plane
INDZ(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating the state of the Z-plane
GGV0(NUMI,NUMJ,NUMK)	R8	I	Porosity (initial value)
GGX0(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in X direction (initial value)
GGY0(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in Y direction (initial value)
GGZ0(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in Z direction (initial value)

XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc
CM0(NUMI,NUMJ,NUMK)	R8	I	inertia coefficient
IELM(23,NELM)	I4	I	Structural Element Data
POS(3,NNOD)	R8	I	Structure nodal point position coordinates
POR(NELM)	R8	I	Gap ratio (stone material)
WK01-04(NUMI,NUMJ,NUMK)	R8	W	Work Array
DBUF(NUMBUF*MAXBUF)	R8	W	Parallel buffer
NFP(NUMI,NUMJ,NUMK)	I4	O	NF of the previous step
INDXP(NUMI,NUMJ,NUMK)	I4	O	INDX in the previous step
INDYP(NUMI,NUMJ,NUMK)	I4	O	INDY in the previous step.
INDZP(NUMI,NUMJ,NUMK)	I4	O	INDZ on the front step

Routine-name	SF_MDPORO		
Function	Calculate fluid cell porosity from interference between structure and fluid cell		
Argument reference module	Type	I/O	Contents
GGV(NUMI,NUMJ,NUMK)	R8	O	Void ratio
GGX(NUMI,NUMJ,NUMK)	R8	O	Area transmittance in X direction
GGY(NUMI,NUMJ,NUMK)	R8	O	Area transmittance in Y direction
GGZ(NUMI,NUMJ,NUMK)	R8	O	Area transmittance in Z direction
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc
IELM(23,NELM)	I4	I	Structural Element Data
GRID(3,NNOD)	R8	I	Structure nodal point position coordinates
POR(NELM)	R8	I	Porosity (stone material)
VV(NUMI,NUMJ,NUMK)	R8	W	Volume of cells interfering with structure
SSX(NUMI,NUMJ,NUMK)	R8	W	Area where X surface interferes with structure
SSY(NUMI,NUMJ,NUMK)	R8	W	Area where Y surface interferes with structure
SSZ(NUMI,NUMJ,NUMK)	R8	W	Area where Z surface interferes with structure
DBUF(NUMBUF*MAXBUF)	R8	W	Parallel buffer

Routine-name	SF_ELEM_RANGE		
Function	Calculate fluid cell porosity from interference between structure and fluid cell		
Argument reference module	Type	I/O	Contents
ISKIP	I4	O	Fluid cell interference flags for structural elements =0 : Possible interference with fluid cells =1 : No possibility of interference with fluid cells
IS	I4	O	Range of fluid cells that may interfere with structural elements I, J, K in the range IS≤I≤IE, JS≤J≤JE, KS≤K≤KE possible interference
IE	I4	O	
JS	I4	O	
JE	I4	O	
KS	I4	O	
KE	I4	O	
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc

EPS	R8	I	Tolerance for range setting
N	I4	I	Number of nodes constituting the structure element
NP(N)	I4	I	Component node number of the structure element
GRID(3,*)	R8	I	Structure nodal point position coordinates

Routine-name	SF_TETDIV		
Function	Split structure elements into multiple tetras		
Argument reference module	Type	I/O	Contents
NT	I4	O	Number of divided tetras
P(3,4,24)	R8	O	Coordinates of the component nodes of the split tetra
N	I4	I	Number of component nodes of the element
NP(N)	I4	I	Component node number of the element
XX(3,*)	R8	I	nodal position coordinates

Routine-name	SF_CUT3		
Function	Calculate volume and area where fluid cells and split tetras interfere		
Argument reference module	Type	I/O	Contents
VV	R8	O	Interfering volumes of fluid cells and split tetras
SX	R8	O	Area of the X-plane of the fluid cell (coordinate XG(1)) covered by the split tetra
SY	R8	O	Area of the Y-plane of the fluid cell (coordinate YG(1)) covered by the split tetra
SZ	R8	O	Area of the Z-plane of the fluid cell (coordinate ZG(1)) covered by the split tetra
P0(3,4)	R8	I	Coordinates of the component nodes of the split tetra
XG(2)	R8	I	X-coordinates of both ends of the cell
YG(2)	R8	I	Y-coordinates of both ends of the cell
ZG(2)	R8	I	Z-coordinates of both ends of the cell
EPS	R8	I	allowable limit of error

Routine-name	SF_NF_RESET		
Function	Update state index based on cell porosity		
Argument reference module	Type	I/O	Contents
NF(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating cell status
INDC(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating the calculation status of the cell
GGV(NUMI,NUMJ,NUMK)	R8	I	porosity
IVOID(NUMI,NUMJ,NUMK)	I4	W	Computed, non-computed flag (0: computed, 1: non-computed)
IBUF(*)	I4	W	Parallel buffer

Routine-name	SF_INDX_RESET		
Function	Resets the state index of the X, Y, and Z planes of the cell		
Argument reference module	Type	I/O	Contents
INDX(NUMI,NUMJ,NU	I4	O	Index indicating the state of the X-plane

MK)			
INDY(NUMI,NUMJ,NUMK)	I4	O	Index indicating the state of the Y-plane
INDZ(NUMI,NUMJ,NUMK)	I4	O	Index indicating the state of the Z-plane
NF(NUMI,NUMJ,NUMK)	I4	I	Index indicating cell status
GGX(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in X direction
GGY(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in Y direction
GGZ(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in Z direction

Routine-name	SF_PFACE2		
Function	Fluid cell number to which the structure surface node belongs, ground flag set to IPGRID0		
Argument Reference Modules	VF_A2ARRAY, SF_ARRAY		
Argument reference module	Type	I/O	Contents
IELM(23,NELM)	I4	I	Structural Element Data
IGNO(NNOD)	I4	I	Node number correspondence table (each process → whole)
IPFACE0(11,NPFC0)	I4	I	Structure surface data (all processes)
IPGRID(2,NNOD)	I4	O	Structure surface nodal data (per process)
IPGRID0(2,NNOD0)	I4	O	Structure surface nodal data (all processes)
POS(3,NNOD)	R8	I	Structure nodal point position coordinates(per process)
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc
NF(NUMI,NUMJ,NUMK)	I4	I	Index indicating cell status

Routine-name	SF_ADJOIN		
Function	Among the cells adjacent to the cell to which the node belongs, take out 7 cells in order from the node to the nearest cell.		
Argument reference module	Type	I/O	Contents
IP(7)	I4	O	Of the cells adjacent to the fluid cell to which the structure node belongs, the L-th nearest cell from the node is as follows (I,J,K) = (IP(L),JP(L),KP(L))
JP(7)	I4	O	
KP(7)	I4	O	
G(3)	R8	I	Location coordinates of structure nodes
X1	R8	I	X-direction end (negative side) coordinates of cell
X2	R8	I	X-direction end (positive side) coordinates of cell
Y1	R8	I	Y-direction end (negative side) coordinates of cell
Y2	R8	I	Y-direction end (positive side) coordinates of cell
Z1	R8	I	Z-direction end (negative side) coordinates of cell

Z2	R8	I	Z-direction end (positive side) coordinates of cell

Routine-name	SF_BC_RESET		
Function	Boundary condition updates		
Argument reference module	Type	I/O	Contents
INDB(MAXB1,NUMB)	I4	O	Boundary surface index
INDBK(MAXBK1,NUMB)	I4	O	Boundary conditions for turbulent energy
INDBE(MAXBE1,NUMB)	I4	O	Boundary conditions for turbulent energy dissipation
INDBT(NUMB)	I4	O	Temperature Boundary Conditions
INDBC(NUMB,LEQC)	I4	O	Boundary conditions for concentration
BCU(NUMB,3)	R8	O	Boundary value of X-directional flow velocity
BCV(NUMB,3)	R8	O	Boundary value of Y-directional flow velocity
BCW(NUMB,3)	R8	O	Boundary value of Z-directional flow velocity
BCP(NUMB,3)	R8	O	Boundary value of pressure
BCF(NUMB)	R8	O	Boundary value of VOF function F
BCVI(NUMB)	R8	O	Boundary conditions for flow velocity (wall roughness)
BCK(NUMB,3)	R8	O	Boundary value of turbulence energy
BCE(NUMB,3)	R8	O	Boundary value of turbulent energy dissipation
BCT(NUMB)	R8	O	Boundary value of temperature
BCTI(2,NUMB)	R8	O	Temperature Boundary Conditions
BCC(NUMB,LEQC)	R8	O	Boundary value of concentration
BCCI(2,NUMB,LEQC)	R8	O	Boundary conditions for concentration
GGX(NUMI,NUMJ,NUMK)	R8	I/O	Area transmittance in X direction
GGY(NUMI,NUMJ,NUMK)	R8	I/O	Area transmittance in Y direction
GGZ(NUMI,NUMJ,NUMK)	R8	I/O	Area transmittance in Z direction
GLX(NUMI,NUMJ,NUMK)	R8	I/O	λ_x
GLY(NUMI,NUMJ,NUMK)	R8	I/O	λ_y
GLZ(NUMI,NUMJ,NUMK)	R8	I/O	λ_z
NF(NUMI,NUMJ,NUMK)	I4	I	Index indicating cell status
INDX(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the X-plane
INDY(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Y-plane
INDZ(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Z-plane
INDX0(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the X-plane（initial value）
INDY0(NUMI,NUMJ,N	I4	I	Index indicating the state of the Y-plane（initial value）

UMK)			
INDZ0(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Z-plane（initial value）
INDB0(MAXB1,NUMB0)	I4	I	Boundary surface index（initial value）
INDBK0(MAXBK1,NUMB0)	I4	I	Boundary conditions for turbulent energy（initial value）
INDBE0(MAXBE1,NUMB0)	I4	I	Boundary conditions for turbulent energy dissipation（initial value）
INDBT0(NUMB0)	I4	I	Temperature Boundary Conditions（initial value）
INDBC0(NUMB0,LEQC)	I4	I	Boundary conditions for concentration（initial value）
BCU0(NUMB0,3)	R8	I	Boundary value of X-directional flow velocity（initial value）
BCV0(NUMB0,3)	R8	I	Boundary value of Y-directional flow velocity（initial value）
BCW0(NUMB0,3)	R8	I	Boundary value of Z-directional flow velocity（initial value）
BCP0(NUMB0,3)	R8	I	Boundary value of pressure（initial value）
BCF0(NUMB0)	R8	I	Boundary value of VOF function F（initial value）
BCVI0(NUMB0)	R8	I	Boundary conditions for flow velocity (wall roughness)（initial value）
BCK0(NUMB0,3)	R8	I	Boundary value of turbulence energy（initial value）
BCE0(NUMB0,3)	R8	I	Boundary of turbulent energy dissipation 値（initial value）
BCT0(NUMB0)	R8	I	Boundary value of temperature（initial value）
BCTI0(2,NUMB0)	R8	I	Temperature Boundary Conditions（initial value）
BCC0(NUMB0,LEQC)	R8	I	Boundary value of concentration（initial value）
BCCI0(2,NUMB0,LEQC)	R8	I	Boundary conditions for concentration（initial value）
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc
IELM(23,NELM)	I4	I	Structural Element Data
POS(3,NNOD)	R8	I	Structure nodal point position coordinates
DVEL(3,NELM)	R8	I	Dulcie flow velocity of the ground

Routine-name	SF_UPDT_OBST, SF_ARRAY		
Function	Update structural nodal, element, and surface data for each process		
Argument Reference Modules	VF_A2ARRAY		
Argument reference module	Type	I/O	Contents
IELM(23,NELM)	I4	I/O	Structural Element Data
POR(NELM)	R8	I/O	porosity(Stone materials)
IENO(NELM)	I4	I/O	Element number correspondence table (each process → whole)
INDG(NNOD)	I4	I/O	Structure node number
IGNO(NNOD)	I4	I/O	Node number correspondence table (each process → whole)
IPFACE(11,NPFC)	I4	I/O	Structure surface data(per process)

IPFNO(NPFC)	I4	I/O	Surface Number Correspondence Table(Each process → Whole)
IPGRID(2,NNOD)	I4	O	(ALLOCATE only)Structure surface nodal data (per process)
PRES(NNOD)	R8	O	(ALLOCATE only)Structure surface nodal pressure(per process)
POS(3,NNOD)	R8	I/O	Structure nodal point position coordinates(per process)
POS1(3,NNOD)	R8	O	(ALLOCATE only)Structure nodal point position coordinates(time:TSTR1)(per process)
POS2(3,NNOD)	R8	O	(ALLOCATE only)Structure nodal point position coordinates(time:TSTR2)(per process)
DVEL(3,NELM)	R8	O	(ALLOCATE only)Dulcie flow velocity of the ground
DVEL1(3,NELM)	R8	O	(ALLOCATE only)Dulcie flow velocity of the ground(time:TSTR1)(per process)
DVEL2(3,NELM)	R8	O	(ALLOCATE only)Dulcie flow velocity of the ground(time:TSTR2)(per process)
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc

Routine-name	SF_CINIT		
Function	Update of flow velocity, pressure, VOF function values and their boundary values and NF, INDS		
Argument reference module	Type	I/O	Contents
XX(MAXG1,NUMI)	R8	I	X-directional grid coordinates, etc
YY(MAXG1,NUMJ)	R8	I	Y-directional grid coordinates, etc
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc
UU(NUMI,NUMJ,NUMK)	R8	I/O	Velocity in X direction
VV(NUMI,NUMJ,NUMK)	R8	I/O	Velocity in Y direction
WW(NUMI,NUMJ,NUMK)	R8	I/O	Velocity in Z direction
PP(NUMI,NUMJ,NUMK)	R8	I/O	Pressure
FF(NUMI,NUMJ,NUMK)	R8	I/O	VOF Function F
FX(NUMI,NUMJ,NUMK)	R8	O	VOF function value in X plane
FY(NUMI,NUMJ,NUMK)	R8	O	VOF function value in Y plane
FZ(NUMI,NUMJ,NUMK)	R8	O	VOF function value in Z plane
ANU(NUMI,NUMJ,NUMK)	R8	I	Sum of molecular kinematic viscosity and eddy kinematic viscosity
GGV(NUMI,NUMJ,NUMK)	R8	I	porosity
GGX(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in X direction
GGY(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in Y direction
GGZ(NUMI,NUMJ,NUMK)	R8	I	Area transmittance in Z direction

BCU(NUMB,3)	R8	I/O	Boundary value of X-directional flow velocity
BCV(NUMB,3)	R8	I/O	Boundary value of Y-directional flow velocity
BCW(NUMB,3)	R8	I/O	Boundary value of Z-directional flow velocity
BCP(NUMB,3)	R8	O	Boundary value of pressure
BCF(NUMB)	R8	O	Boundary value of VOF function F
BCVI(NUMB)	R8	I	Boundary conditions for flow velocity (wall roughness)
DMTBTT(MTBTT)	R8	I	Dimensionless phase of matrix data
DMTBZZ(MTBZZ)	R8	I	Z-coordinate of matrix data (mean water level is zero)
DMTBHH(MTBTT)	R8	I	Water level in matrix data
DMTBUN(MTBZZ,MTBTT)	R8	I	Horizontal flow velocity in matrix data
DMTBUT(MTBZZ,MTBTT)	R8	I	Vertical flow velocity in matrix data
DBUF(*)	R8	W	Parallel buffer
WK01-03(NUMI,NUMJ,NUMK)	R8	W	Work Array
NF(NUMI,NUMJ,NUMK)	I4	I/O	Index indicating cell status
INDX(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the X-plane
INDY(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Y-plane
INDZ(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Z-plane
INDB(MAXB1,NUMB)	I4	I	Boundary surface index
INDS(NUMI*NUMJ*NUMK)	I4	O	I, J, K coordinates of surface cells (I+NUMI*(J-1)+NUMI*NUMJ*(K-1))
IBUF(*)	I4	W	Parallel buffer
NFP(NUMI,NUMJ,NUMK)	I4	I	NF in the previous step
INDXP(NUMI,NUMJ,NUMK)	I4	I	INDX in the previous step
INDYP(NUMI,NUMJ,NUMK)	I4	I	INDY in the previous step.
INDZP(NUMI,NUMJ,NUMK)	I4	I	INDZ in the previous step

Routine-name	SF_GPRES		
Function	Interpolate fluid cell pressure to obtain pressure at structure surface nodes		
Argument reference module	Type	I/O	Contents
PRES0(NNOD0)	R8	O	Structure surface nodal pressure(whole process)
PRES(NNOD)	R8	W	Structure surface nodal pressure(per process)
PP(NUMI,NUMJ,NUMK)	R8	I	Fluid cell pressure
IPGRID(2,NNOD)	I4	I	Structure surface nodal data (per process)
IGNO(NNOD)	I4	I	Node number correspondence table (each process → whole)
POS(3,NNOD)	R8	I	Structure nodal point position coordinates(per process)
ZZ(MAXG1,NUMK)	R8	I	Z-directional grid coordinates, etc
NF(NUMI,NUMJ,NUMK)	I4	I	Index indicating cell status

Routine-name	SF_PMGBC0		
Function	Set the boundary conditions received from CADMAS-MG in the table of initial boundary condition values		
Argument reference module	Type	I/O	Contents
BCU0(NUMB0,3)	R8	O	Boundary value of X-directional flow velocity（initial value）
BCV0(NUMB0,3)	R8	O	Boundary value of Y-directional flow velocity（initial value）
BCW0(NUMB0,3)	R8	O	Boundary value of Z-directional flow velocity（initial value）
BCP0(NUMB0,3)	R8	O	Boundary value of pressure（initial value）
BCF0(NUMB0)	R8	O	Boundary value of VOF function F（initial value）
INDX0(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the X-plane（initial value）
INDY0(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Y-plane（initial value）
BCU(NUMB,3)	R8	I	Boundary value of X-directional flow velocity
BCV(NUMB,3)	R8	I	Boundary value of Y-directional flow velocity
BCW(NUMB,3)	R8	I	Boundary value of Z-directional flow velocity
BCP(NUMB,3)	R8	I	Boundary value of pressure
BCF(NUMB)	R8	I	Boundary value of VOF function F
INDX(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the X-plane
INDY(NUMI,NUMJ,NUMK)	I4	I	Index indicating the state of the Y-plane

Routine-name	SF_MPI_*
Function	Routines for inter-process communication in CADMAS

Routine-name	SF_C_MPI_*
Function	Routines for communication between processes in CADMAS and STR