Explanation on VS Style Matrix Format

1. VS Style Matrix Format

VS Style Matrix Format is a type of text format for storing matrix data for numerical analyses.　A matrix data using VS Style Matrix Format consists of the following five (5) types of text files.

Table 1.　Files Composing the VS Style Matrix Format

File Name	Descriptions of Data Stored	Number of Types of Physical Quantity		
		1	2 or more	Shell Elements
[file name].vs1	coefficient matrix (A)	+	+	+
[file name].vs2	right-hand side vector (B)	+	+	+
[file name].vs3	solution vector (X)	=	=	=
[file name].vs4	physical quantity type information for all unknowns (LPV)	×	+	+
[file name].vs5	node information for all unknowns	×	+	+
[file name].vs6	coordinate vector	×	=	+

Note: "+" indicates required files;

"=" indicates files that may not be required;

"x" indicates the files that are not required

e.g.) In order to analyze a problem with only one type of physical quantity (degree of freedom = 1), both "vs1" and "vs2" files are required.　In order to analyze a problem with the number of types of physical value (degree of freedom) of 2 or more, all of the following 4 files are required: "vs1", "vs2", "vs3" and "vs4".
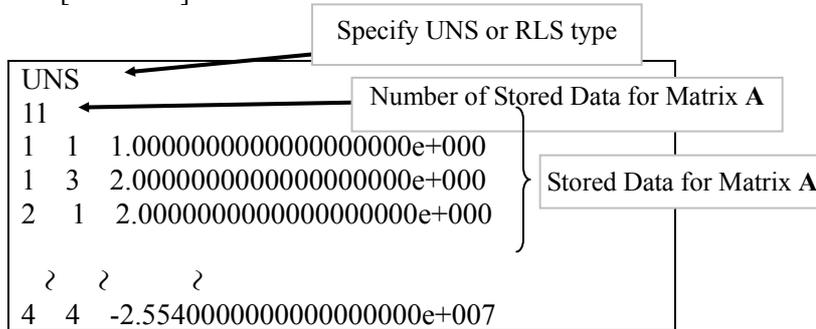
2. Common Rules for All Files

The following rules are common among each of 6 types of text files for VS Style Matrix Format:

A) text data

B) use half-size space or tab as delimiter

C) when data are real numbers, enter as 20-digit significant figures (depending on the problem, if the significant digit is small, the correct solution may not be obtained due to cancellation of significant digits.

D) Store data in ascending order of row, column and/or node numbers (follow the explanations provided in the following section, 3. Details of Each File, regarding whether or not each file includes row, column or node).

3. Details of Each File

The following sub-sections explain the details of each file.

3.1. [file name].vs1

```
┌──────────────────────────┐
│  Specify UNS or RLS type │
└──────────────────────────┘
UNS ◄───────────
11  ◄──────────────────  ┌────────────────────────────────────┐
1   1   1.000000000000000000e+000   │ Number of Stored Data for Matrix A │
1   3   2.000000000000000000e+000   └────────────────────────────────────┘
2   1   2.000000000000000000e+000   ┌──────────────────────────┐
                                     │ Stored Data for Matrix A │
   ≀   ≀       ≀                     └──────────────────────────┘
4   4   -2.554000000000000000e+007
```

Note: UNS type: UNSTRUCTURED;

RLS type: REAL SYNMETRIC;

Stored Data: Data of diagonal elements + Data of non-zero non-diagonal elements

3.1.1. First Line

Designates the type of matrix by specifying either "RLS" or "UNS" (while the type specification is not case sensitive, use either upper case letters only or lower case letters only for an ease of view). When the type is not specified, UNS type is assumed.

Specifying RLS type:

RLS type can be used only for matrices with the number of types of physical quantity (degree of freedom) 1.

Thus, when the number of types of physical quantity (degree of freedom) is 2 or more, please use UNS type even if the matrix is symmetric. Store the data for the diagonal elements and the upper-right-hand triangle portion of the matrix only. You'll receive an error message, when the data is found on both sides of the diagonal elements.

Specifying UNS Format:

When the number of types of physical quantity (degree of freedom) is 2 or more, you must provide information to identify which node and which type of physical quantity each unknown represents for by using "vs4" and "vs5" files.

If any or both of "vs4" and "vs5" files are missing, the problem will be treated as a single quantity (degree of freedom = 1) problem.

3.1.2. Second Line

Define the number of data stored for matrix A in the second line.

3.1.3. Third and Following Lines

In the third and following lines, enter the "value of data stored for coefficient matrix **A**" in the order of row number, column number, and the value of data stored.

3.2. [file name].vs2

```
4                          Number of elements of Right-Hand Side Vector B
1   1.0000000000000000000e+000
2   0.0000000000000000000e+000
3   0.3333333333333333333e+000      Data for Right-Hand Side Vector B
4   1.0000000000000000000e+000
```

3.2.1. First Line

Enter the number of elements of the right-hand side vector **B** in the first line.   The number of elements of the right-hand side vector **B** is the same as the number of unknowns (ND).

3.2.2. Second and Following Lines

In the second and following lines, enter the "value of the data in the right-hand side vector B" in the order of row number first and then the value of element.

3.3. [file name].vs3

```
4                          Number of Element of Solution Vector X
1   1.0000000000000000000e+000
2   1.0000429057789099999e+004
3   7.9056788819040009003e-003      Data for Solution Vector X
4  -2.0478270000000090055e+000
```
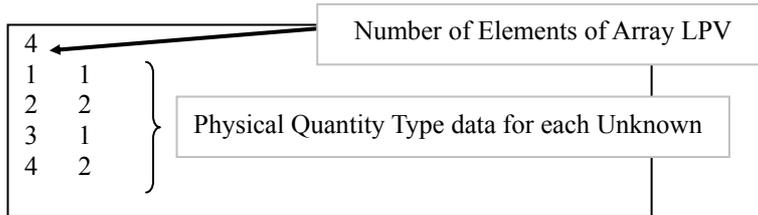
3.3.1. First Line

Define the number of elements of the solution vector **X** in the first line.   The number of elements of the solution vector **X** is the same as the number of unknowns (ND).

3.3.2. Second and Following Lines

Enter the "data of solution vector **X**" in the order of row number first and then the value of solution.

3.4. [file name].vs 4

```
4            Number of Elements of Array LPV
1    1
2    2       Physical Quantity Type data for each Unknown
3    1
4    2
```
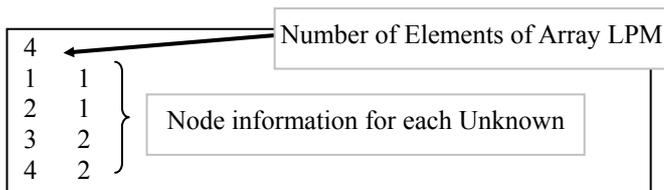
3.4.1. First Line

Enter the number of elements of Array LPV in the first line.   The number of the elements of Array LPV is the same as the number of unknowns (ND).

3.4.2. Second and Following Lines

In the second and following lines, enter "row number" and "the value that identifies which physical quantity the unknown x represents" in the same order of elements in unknown vector x.

3.5. [file name].vs5

```
4            Number of Elements of Array LPM
1    1
2    1       Node information for each Unknown
3    2
4    2
```
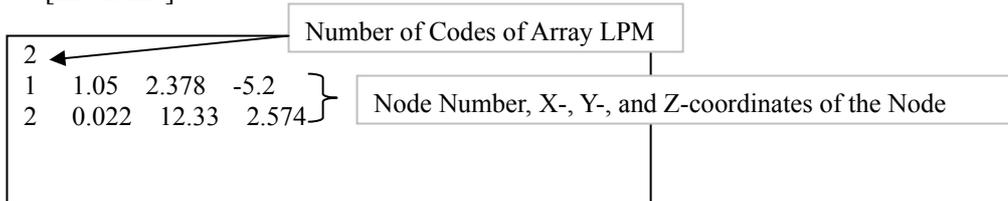
3.5.1. First Line

Describe the number of elements of array LPM in the first line.   The number of elements of array LPM is the same as the number of unknowns (ND).

3.5.2. Second and Following Lines

In the second and following lines, enter "row number" and "the value that identifies which node the unknown x represent", in the order of elements in unknown vector x.   As long as the node number is greater than 1, the do not need to be sequential.

3.6. [file name].vs6

```
                    ┌─────────────────────────────────┐
              ┌─────│  Number of Codes of Array LPM   │
  2  ◄────────┘     └─────────────────────────────────┘
  1   1.05   2.378   -5.2    ⎤   ┌──────────────────────────────────────────────┐
  2   0.022  12.33   2.574   ⎦   │  Node Number, X-, Y-, and Z-coordinates of the Node │
                                 └──────────────────────────────────────────────┘
```

3.6.1. First Line

Enter the number of codes included in array LPM in the first line.   Note that this value
would be smaller than the maximum value of the node number, if the node numbers are not
sequential.

3.6.2. Second and Following Lines

In the second and following lines, enter the "node number" and "X-, Y- and Z-coordinates
of the node".

4. Examples

4.1. Storing data in "vs1" file (UNS type)

In a simultaneous linear equation $Ax = B$, suppose that coefficient Matrix **A** is as follows:

$$A = \begin{pmatrix} 1.0 & 0.0 & 2.0 & 0.0 \\ 2.0 & 3.0 & 0.0 & 4.0 \\ 4.0 & 1.0 & 5.0 & 3.0 \\ 0.0 & 6.0 & 0.0 & 6.0 \end{pmatrix}$$

Explanatory Notes	
	Diagonal Elements
	Non-zero, Non-diagonal Elements
	Zero Elements of Non-diagonals

This coefficient matrix A is not symmetrical, thus you must use UNS format.

For UNS format, enter "UNS" in the first line of "vs1" file (see the example below).

UNS
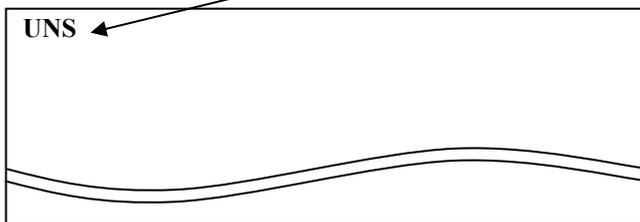
In the second line of "vs1" file, enter the number of non-zero elements in coefficient matrix A (in this example, 11).

UNS
11
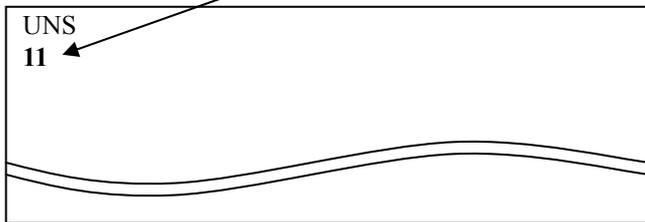
In the third and following lines, enter the non-zero elements of the coefficient matrix A in ascending order of rows and columns. Among the data for the same row number, enter the smaller column number before larger column number.

In the **third and the following lines of vs1 file**, enter: row number, space*, column number, space*, non-zero elements (in 20 significant digits).   (*when the space bar is used as delimiter)

UNS
11
1 1 1.0000000000000000000e+000
1 3 2.0000000000000000000e+000
2 1 2.0000000000000000000e+000
2 2 3.0000000000000000000e+000
2 4 4.0000000000000000000e+000
3 1 4.0000000000000000000e+000
3 2 1.0000000000000000000e+000
3 3 5.0000000000000000000e+000
3 4 3.0000000000000000000e+000
4 2 6.0000000000000000000e+000
4 4 6.0000000000000000000e+000

4.2. Storing data in "vs1" file (RLS type)

In a simultaneous linear equation $Ax = B$, suppose that coefficient Matrix **A** is as follows:

$$A = \begin{pmatrix} 1.0 & 0.0 & 2.0 & 0.0 \\ 0.0 & 3.0 & 0.0 & 4.0 \\ 2.0 & 0.0 & 5.0 & 3.0 \\ 0.0 & 4.0 & 3.0 & 6.0 \end{pmatrix}$$

Explanatory Notes	
	Diagonal Elements
	Non-zero, Non-diagonal Elements
	Zero Elements of Non-diagonals

The RLS format is symmetric to the diagonals of the matrix.   The coefficient matrix A in the example above can be entered in RLS format because it is symmetric.   By using RLS format, the amount of data can be reduced when compared with UNS format.

However, you can still use UNS format, if you prefer.

If the data contains LPV and LPM arrays, you must use UNS format.

In this format, upper half elements from the diagonals are entered.

$$A = \begin{pmatrix} 1.0 & 0.0 & 2.0 & 0.0 \\ & 3.0 & 0.0 & 4.0 \\ & & 5.0 & 3.0 \\ & & & 6.0 \end{pmatrix}$$

Enter "RLS" in the first line of vs1 file.

RLS
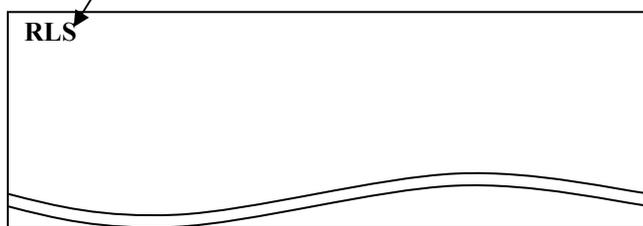
The number of non-zero elements in the coefficient matrix A, which goes into the second line, is in this case 7, because we enter upper half elements in the matrix only.

RLS
7

7

Non-zero elements in the upper half of coefficient matrix A must be entered into the third and following lines.

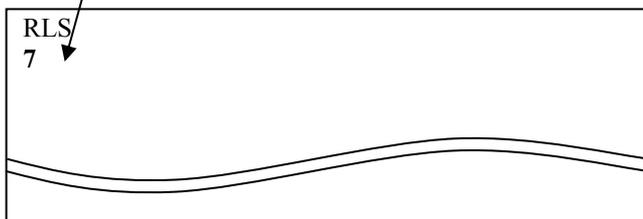The order of data entry is ascending order of row number, and ascending order or column for the data for the same row.

In the **third and the following lines of vs1 file**, enter: **row number, space*, column number, space*, and the value of the non-zero elements** (in 20 significant digits). (*when the space bar is used as delimiter)

```
RLS
7
1 1 1.0000000000000000000e+000
1 3 2.0000000000000000000e+000
2 2 3.0000000000000000000e+000
2 4 4.0000000000000000000e+000
3 3 5.0000000000000000000e+000
3 4 3.0000000000000000000e+000
4 4 6.0000000000000000000e+000
```

4.3. Storing data in vs2 file

In a simultaneous linear equation *Ax* = *B,*

suppose that the right-hand side vector B is as follows.

$$
B = \begin{bmatrix} 16.0 \\ 34.0 \\ 20.0 \\ 40.0 \end{bmatrix}
$$

In the **first line of vs2 file**, enter the **number of elements in the right-hand side vector B**, which is 4 in this example.

```
4
```

In the second and following lines, enter the element values of elements in the right-hand side vector B, in the order of ascending row number.

In the **second and the following lines of vs2 file**, enter: **row number, space*,** and the **value of the elements (in 20 significant digits).**   (*when the space bar is used as delimiter)

```
4
1    1.6000000000000000000e+001
2    3.4000000000000000000e+001
3    2.0000000000000000000e+001
4    4.0000000000000000000e+001
```

4.4. Storing data in vs3 file

In a simultaneous equation $Ax = B$, suppose that solution vector x is as follows.

$$x = \begin{bmatrix} 1.0 \\ 2.0 \\ 3.0 \\ 4.0 \end{bmatrix}$$

In the first line of vs3 file, **enter the number of the elements in the solution vector x, which is 4 in this example.**

```
4
```

In the second and the following lines, enter the values of elements in the solution vector x, in the order of ascending row number.

In the **second and the following lines of vs3 file**, enter: **row number, space*,** and the **value of the element** (in 20 significant digits).   (*when the space bar is used as delimiter)
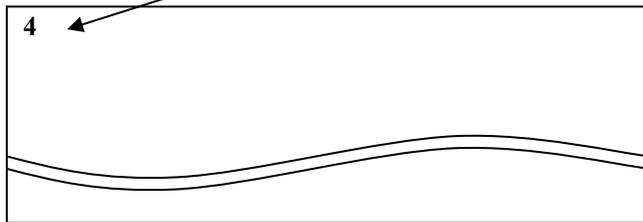
```
4
1   1.0000000000000000000e+000
2   2.0000000000000000000e+000
3   3.0000000000000000000e+000
4   4.0000000000000000000e+000
```

9
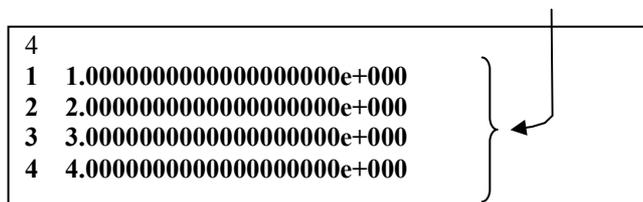
4.5. Storing data in vs4 and vs5 files

When solving a simultaneous linear equation system with multiple physical quantities (a coupled analysis), information is needed to identify which node and which type of physical quantity each unknown represents for. For this purpose, following two data must be present.

    (1) Physical quantity type information for each unknown. (LPV)

    (2) Node information for each unknown. (LPM)

    LPV (physical quantity type information for each unknown) is stored in vs4 file; and LPM (node information for each unknown) is stored in vs5 file.

Example) In the analysis model used to derive the simultaneous equation system, assign a node number to each node in the mesh. Node numbers must be integer equal to or greater than 1, and each node must have unique node number.
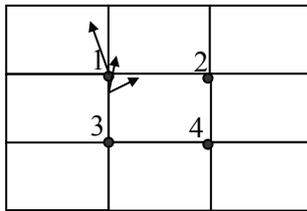
Also, integer numbers (1 to NV) must be assigned to each type of physical quantity used in the model.

For example, when solving three velocity components in a coupled analysis, NV, the number of types of physical quantity, equals 3, and you can assign the physical quantity type number as follows.

    x-velocity: $u = 1$,

    y-velocity: $v = 2$,

    z-velocity: $w = 3$

Suppose that linear equations in the system is given in the following order.

    ・Equation of x-velocity of node 1

    ・Equation of y-velocity of node 1

    ・Equation of z-velocity of node 1

          〳

    ・   Equation of x-velocity of node 4

    ・   Equation of y-velocity of node 4

    ・   Equation of z-velocity of node 4

The number of equations is the same as the number of dimension (ND).

LPV and LPM vectors are as follows.

i	Node information	Physical quantity type information
1	Node 1	$u(\,1\,)$
2	Node 1	$v(\,2\,)$
3	Node 1	$w(\,3\,)$
4	Node 2	$u(\,1\,)$
5	Node 2	$v(\,2\,)$
6	Node 2	$w(\,3\,)$
$\}$	$\}$	$\}$
ND		

Therefore, values of LPV and LPM in this example are as follows.

i	LPM	LPV
1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3
7	3	1
8	3	2
9	3	3
10	4	1
11	4	2
12	4	3

Based on above, entry to the first line of vs4 file, which is the number of elements in the array LPV, is 12.

In the second and the following lines, enter the values of elements in the array LPV, in the order of ascending row number.

In the **second and the following lines of vs4 file**, enter: **row number, space*,** and the **value of the element of LPV array** (in 20 significant digits).   (*when the space bar is used as delimiter)

```
12
  1   1
  2   2
  3   3
  4   1
  5   2
  6   3
  7   1
  8   2
  9   3
 10   1
 11   2
 12   3
```

Similarly, enter the **number of elements in the array LPM** in the **first line of vs5 line** (which is 12 in this example).

```
12
```

In the second and the following lines, enter the values of elements in the array LPM, in the order of ascending row number.

In the **second and the following lines of vs5 file**, enter: **row number, space*, and the value of the element of LPM array** (in 20 significant digits).   (*when the space bar is used as delimiter)

```
12
  1   1
  2   1
  3   1
  4   2
  5   2
  6   2
  7   3
  8   3
  9   3
 10   4
 11   4
 12   4
```

4.6. Storing data in vs6 file

Coordinate values of nodes as used in vs5 file (LPM) for node identification information for each unknown are stored in vs6 file.

In the **first line of vs6 file**, enter the **number of elements in the array LPM**, which is 4 in this example.

```
4
```

In the second and the following lines, enter the values of elements in the array LPM and corresponding coordinate values for the node, in the order of ascending row number.

In the **second and the following lines of vs6 file**, enter: **value of LPM element, space*, X-coordinate, space*, Y-coordinate, space* and Z-coordinate (in 20 significant digits).** (*when the space bar is used as delimiter)

```
4
  1   1.35   2.46   3.33
  2   6.79   5.64   2.89
  3   7.12   2.34   5.91
  4   2.21   1.98   3.32

LPM   X     Y      Z
```