*INTEGRATION

In this section the user defined integration rules for beam and shell elements are specified. IRID refers to integration rule identification number on *SECTION_BEAM and *SECTION_SHELL cards respectively. Quadrature rules in the *SECTION_SHELL and *SECTION_BEAM cards need to be specified as a negative number. The absolute value of the negative number refers to user defined integration rule number. Positive rule numbers refer to the built in quadrature rules within LS-DYNA. The keyword cards in this section are:

*INTEGRATION_BEAM

*INTEGRATION_SHELL

*INTEGRATION_BEAM

Purpose: To support user defined through the thickness integration rules for the beam element.

Card 1	1	2	3	4	5	6	7	8
Variable	IRID	NIP	RA	ICST	K			
Type	I	I	F	I	I			
Default	none	0	0.0	0	0			

Standard Cross-Section Card. Additional card for ICST > 0.

Card 2	1	2	3	4	5	6	7	8
Variable	D1	D2	D3	D4	SREF	TREF	D5	D6
Type	F	F	F	F	F	F	F	F
Default	none	none	none	none	0.0	0.0	none	none

Quadrature Cards. Include NIP additional cards below for NIP ≠ 0.

Card 3	1	2	3	4	5	6	7	8
Variable	S	T	WF	PID				
Type	F	F	F	I				

VARIABLE	DESCRIPTION
IRID	Integration rule ID. IRID refers to IRID on *SECTION_BEAM card.
NIP	Number of integration points; see also ICST.
RA	Relative area of cross section, that is, the actual cross-sectional area divided by the area defined by the product of the specified thickness in the *s*-direction and the thickness in the *t*-direction. See also

VARIABLE	DESCRIPTION
	ICST below and Figure 29-1.
ICST	Standard cross section type. If this type is nonzero, then NIP and the relative area above should be input as zero. See shapes in Figures 29-3 through 29-24. EQ.01: I-Shape EQ.02: Channel EQ.03: L-shape EQ.04: T-shape EQ.05: Tubular box EQ.06: Z-Shape EQ.07: Trapezoidal EQ.08: Circular EQ.09: Tubular EQ.10: I-Shape 2 EQ.11: Solid Box EQ.12: Cross EQ.13: H-Shape EQ.14: T-Shape 2 EQ.15: I-Shape 3 EQ.16: Channel 2 EQ.17: Channel 3 EQ.18: T-Shape 3 EQ.19: Box-Shape 2 EQ.20: Hexagon EQ.21: Hat-Shape EQ.22: Hat-Shape 2
K	Integration refinement parameter, k, for standard cross section types. Select an integer ≥ 0. See Figures 29-3 through 29-24.
D1-D6	Cross-section dimensions. See Figures 29-3 through 29-24.
SREF	s_{ref}, location of reference surface normal to s, for the Hughes-Liu beam only. This option is only useful if the beam is connected to a shell or another beam on its outer surface. Overrides NSLOC in *SECTION_BEAM, even if SREF = 0.
TREF	t_{ref}, location of reference surface normal to t, for the Hughes-Liu beam only. This option is only useful if the beam is connected to a shell or another beam on its outer surface. Overrides NTLOC in *SECTION_BEAM, even if TREF = 0.
S	Normalized s-coordinate of integration point, $-1 \le s \le 1$.
T	Normalized t-coordinate of integration point, $-1 \le t \le 1$.
WF	Weighting factor, A_{ri}, that is the area associated with the integration point divided by actual cross sectional area $A_{ri} = A_i/A$; see Figure 29-2.

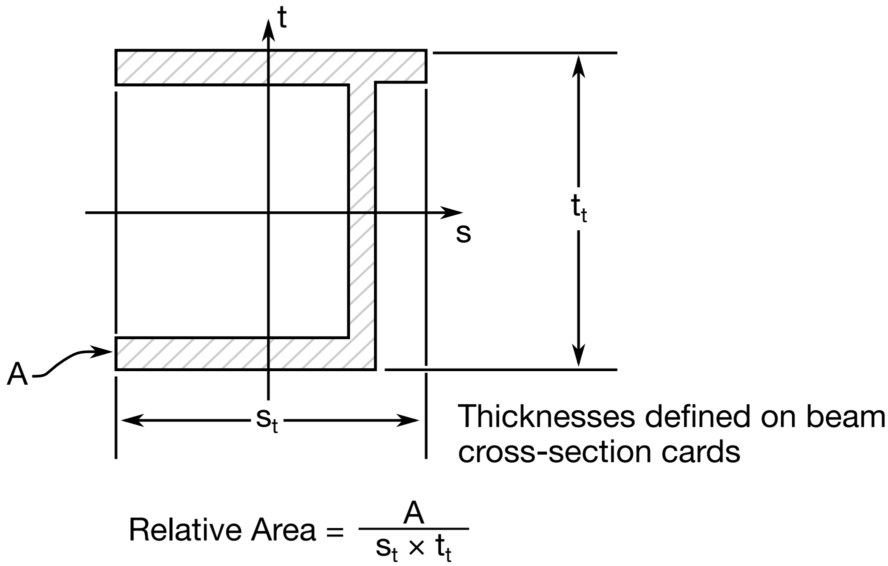


Figure 29-1. Definition of relative area for user defined integration rule.

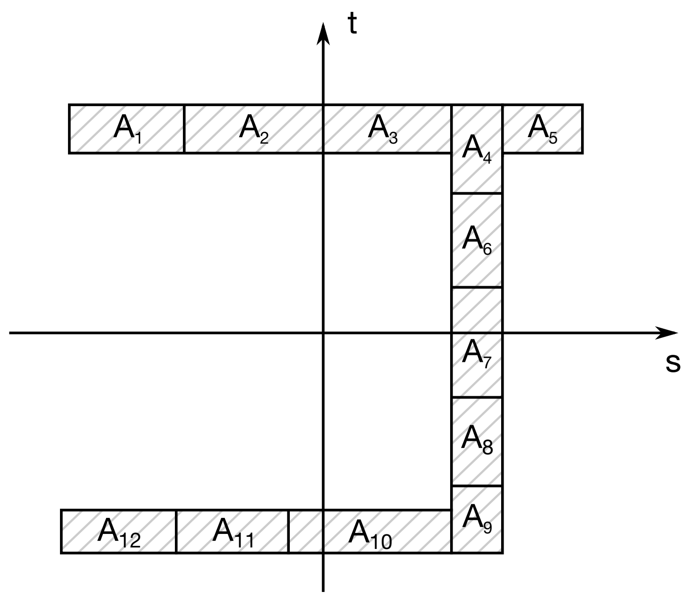


Figure 29-2. Definition of integration points for user defined integration rule.

VARIABLE	DESCRIPTION
PID	Optional PID, used to identify material properties for this integration point. If zero, the PID referenced on *ELEMENT_BEAM will be used.

Remarks:

The input for standard beam section types is defined below. In the following figures the dimensions are shown on the left and the location of the integration points are shown on the right. If a quantity is not defined in the sketch, then it should be set to zero in the input. The input quantities include:

D1 - D6	=	Dimensions of section
k	=	Integration refinement parameter (an integer ≥ 0)
s_{ref}	=	location of reference surface normal to s, Hughes-Liu beam only
t_{ref}	=	location of reference surface normal to t, Hughes-Liu beam only

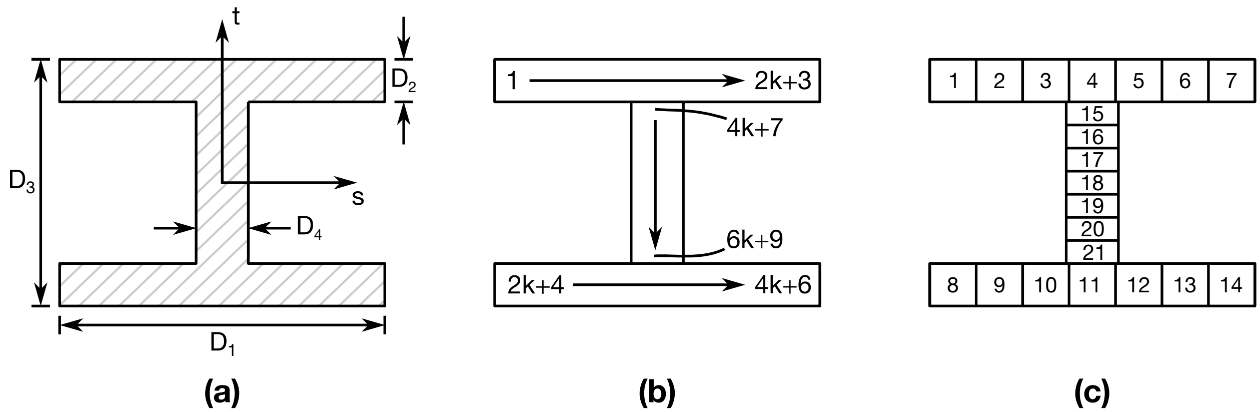


Figure 29-3. Type 1: I-Shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

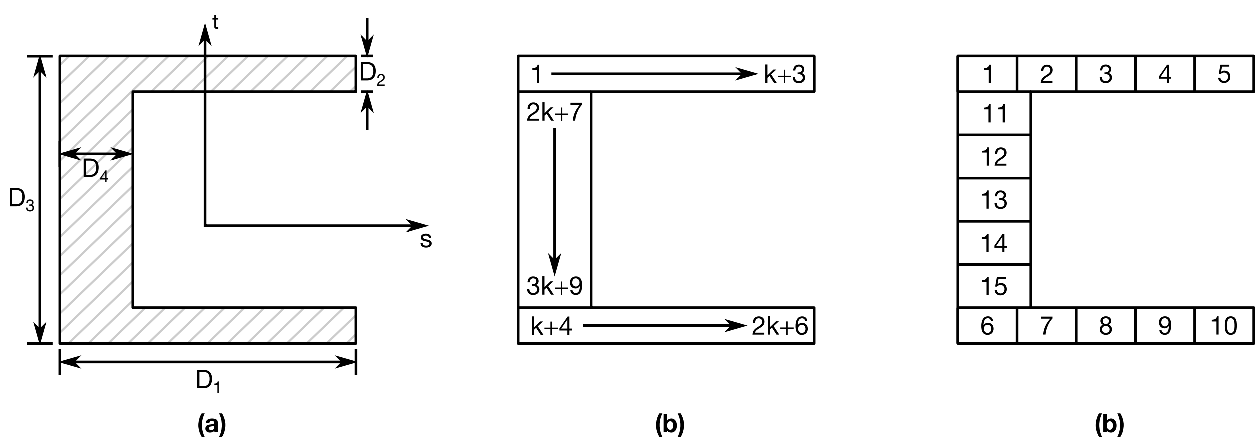


Figure 29-4. Type 2: Channel. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

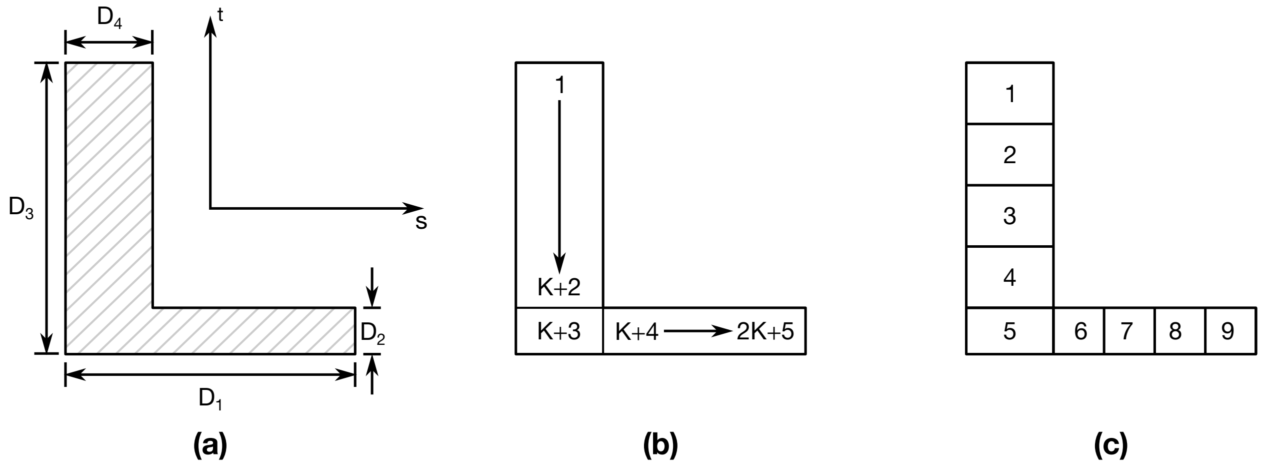


Figure 29-5. Type 3: L-shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

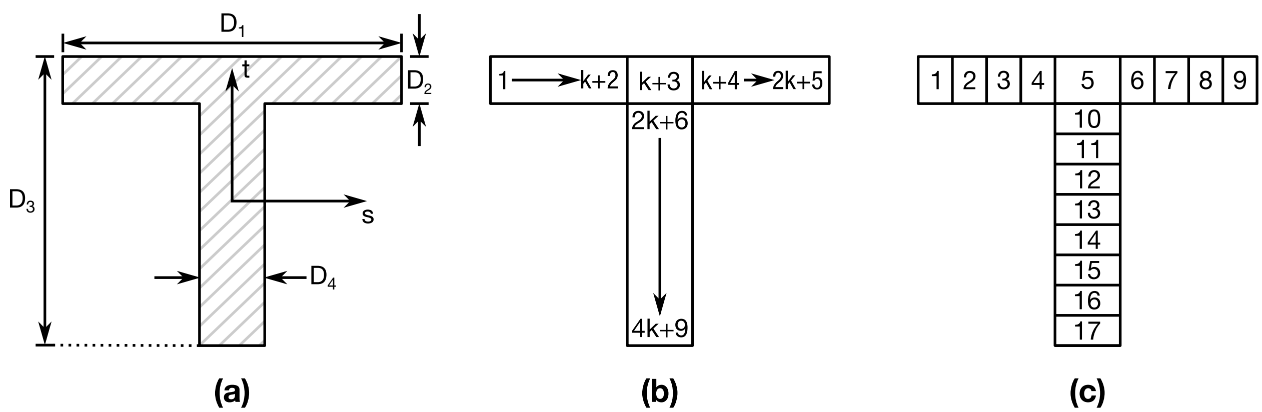


Figure 29-6. Type 4: T-shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

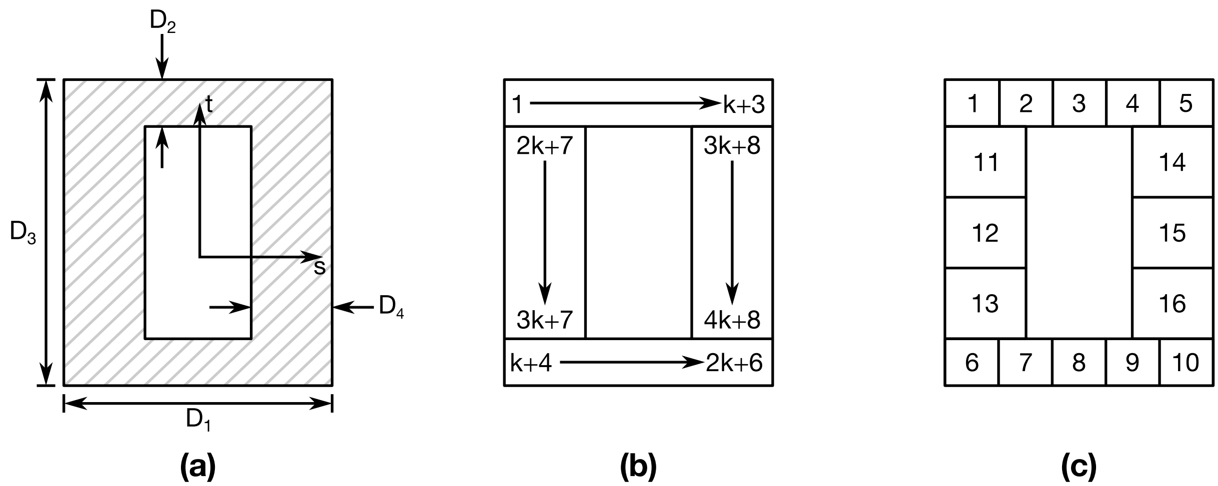


Figure 29-7. Type 5: Box-shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

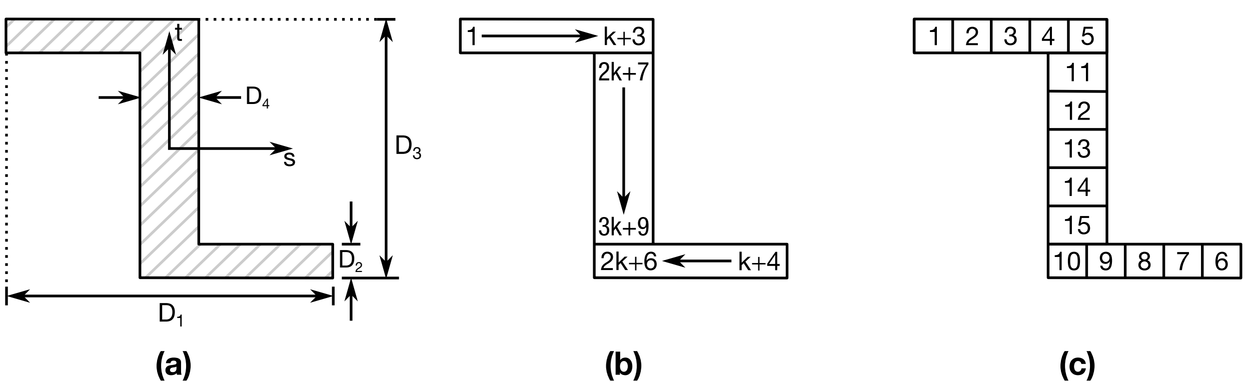


Figure 29-8. Type 6: Z-shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

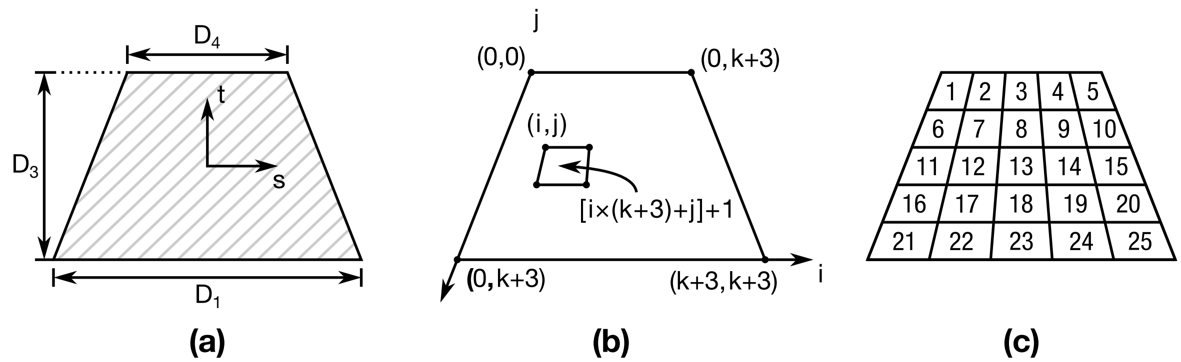


Figure 29-9. Type 7: Trapezoidal. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

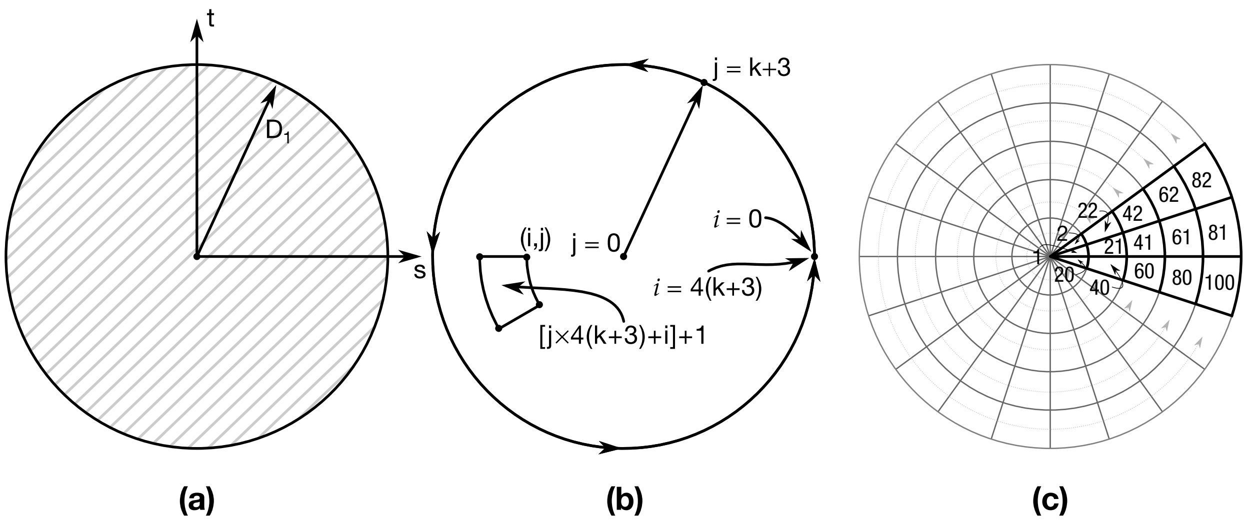


Figure 29-10. Type 8: Circular. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

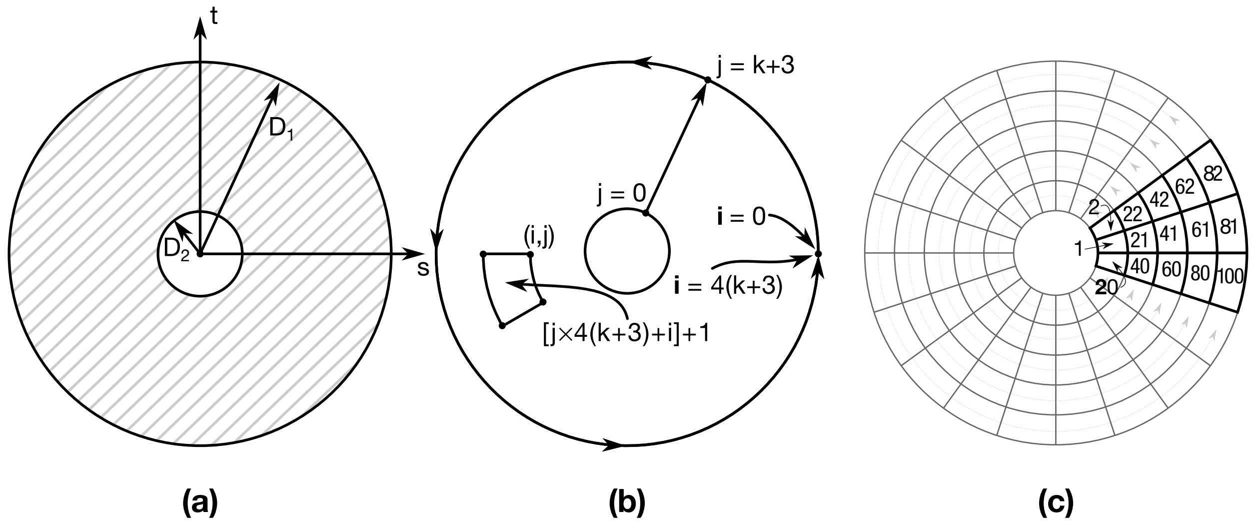


Figure 29-11. Type 9: Tubular. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

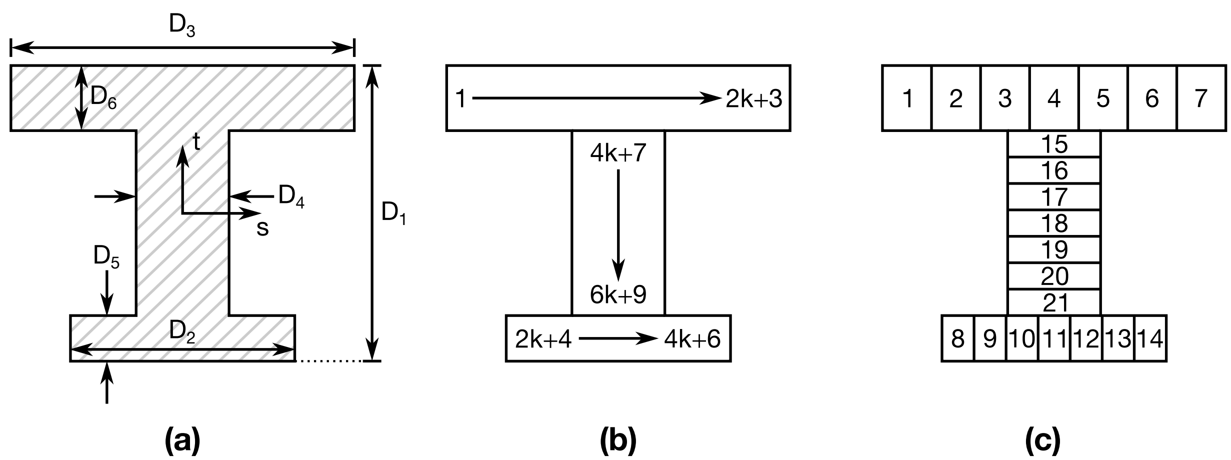


Figure 29-12. Type 10: I-Shape 2. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

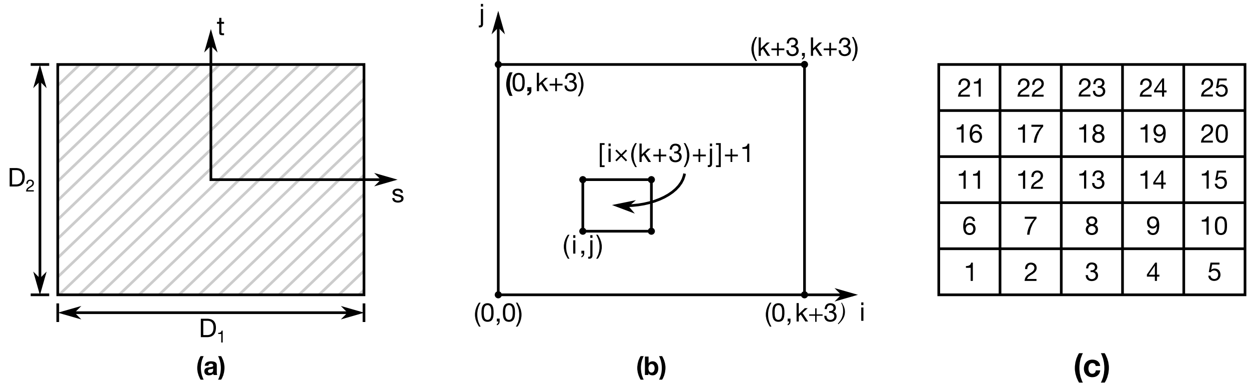


Figure 29-13. Type 11: Solid Box. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

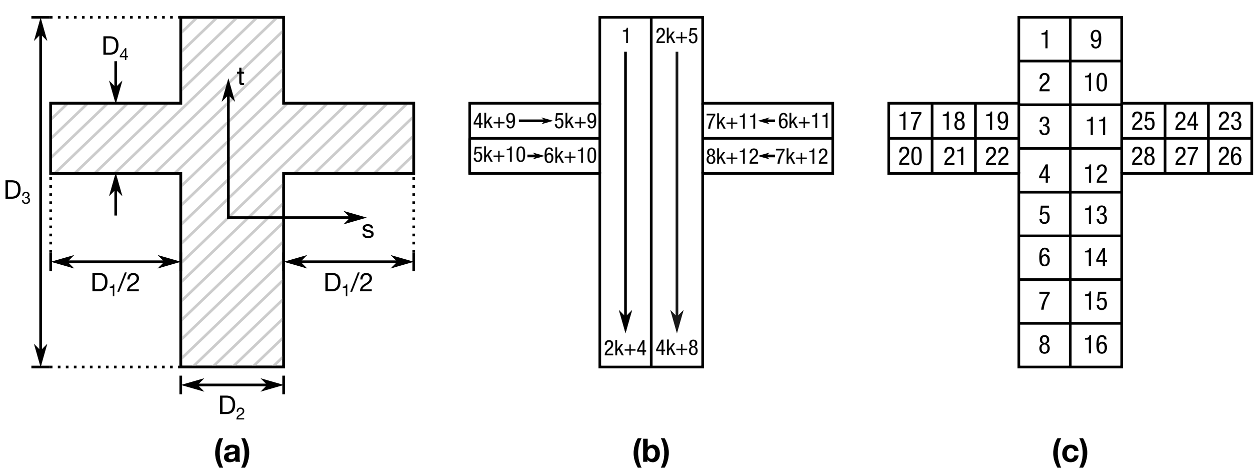


Figure 29-14. Type 12: Cross. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

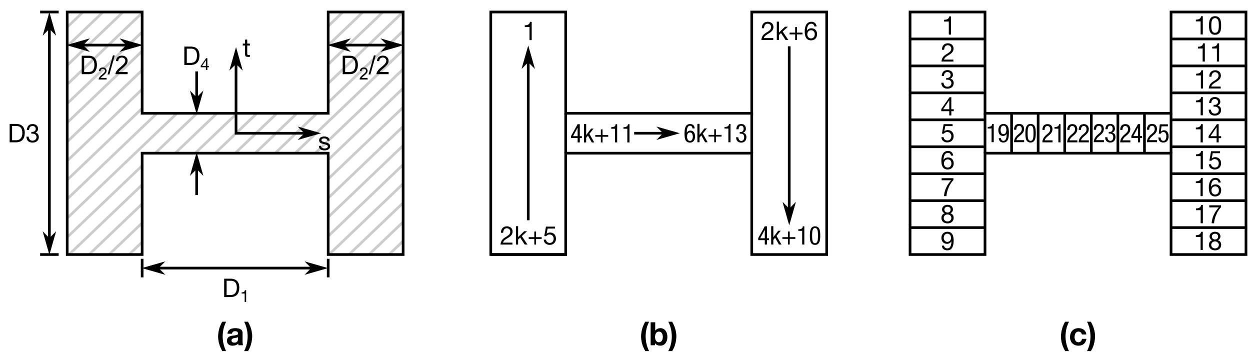


Figure 29-15. Type 13: H-Shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

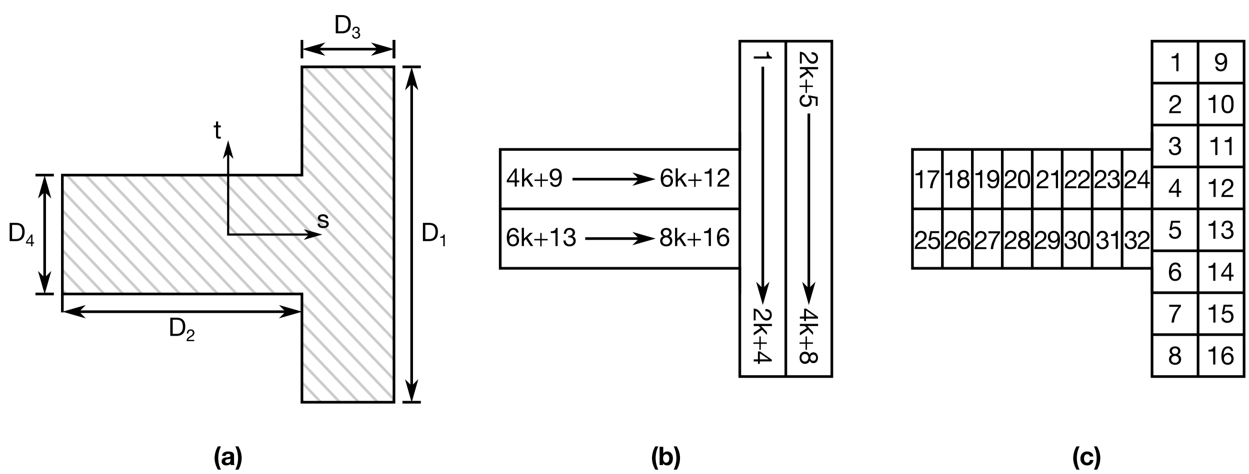
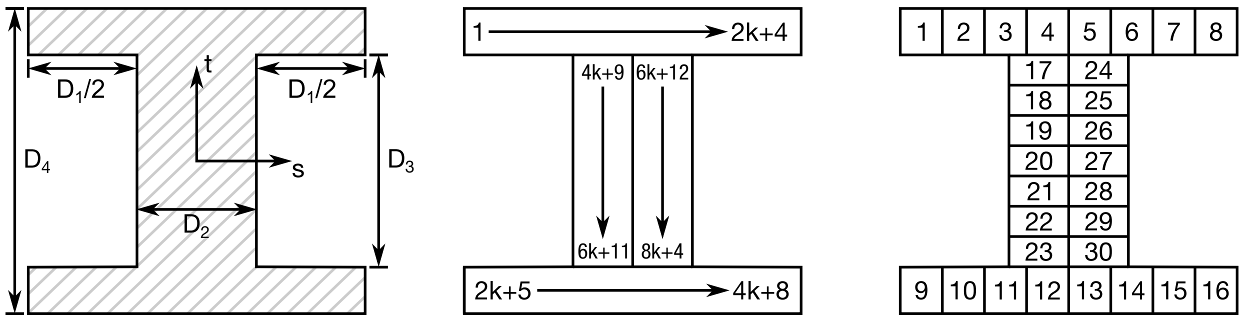
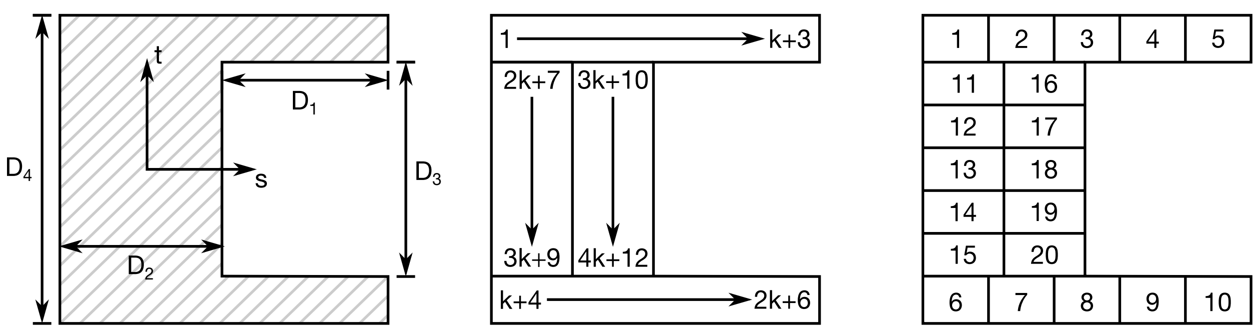


Figure 29-16. Type 14: T-Shape 2. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.



(a) (b) (c)

Figure 29-17. Type 15: I-Shape 3. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.



(a) (b) (c)

Figure 29-18. Type 16: Channel 2. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

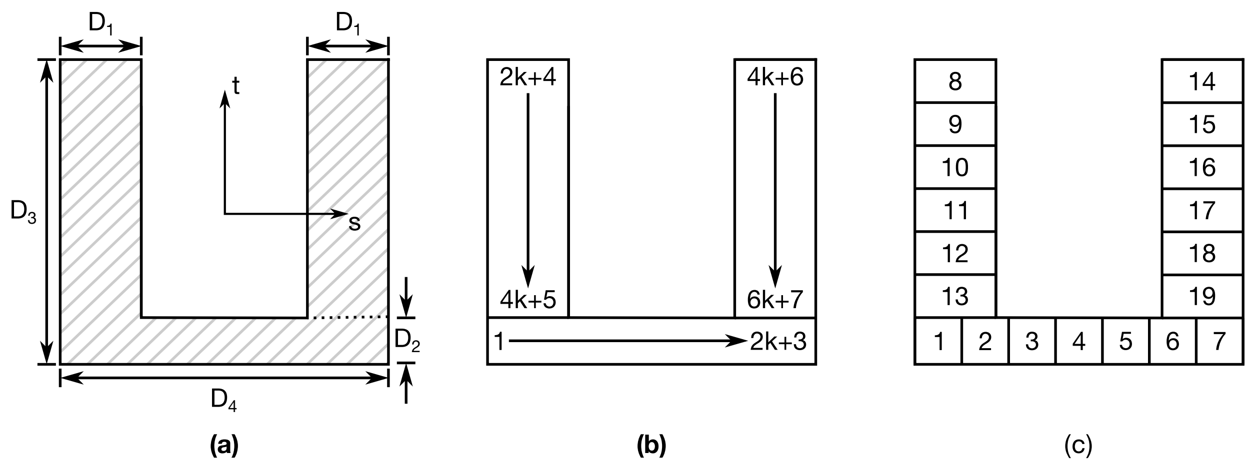


Figure 29-19. Type 17: Channel 3. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

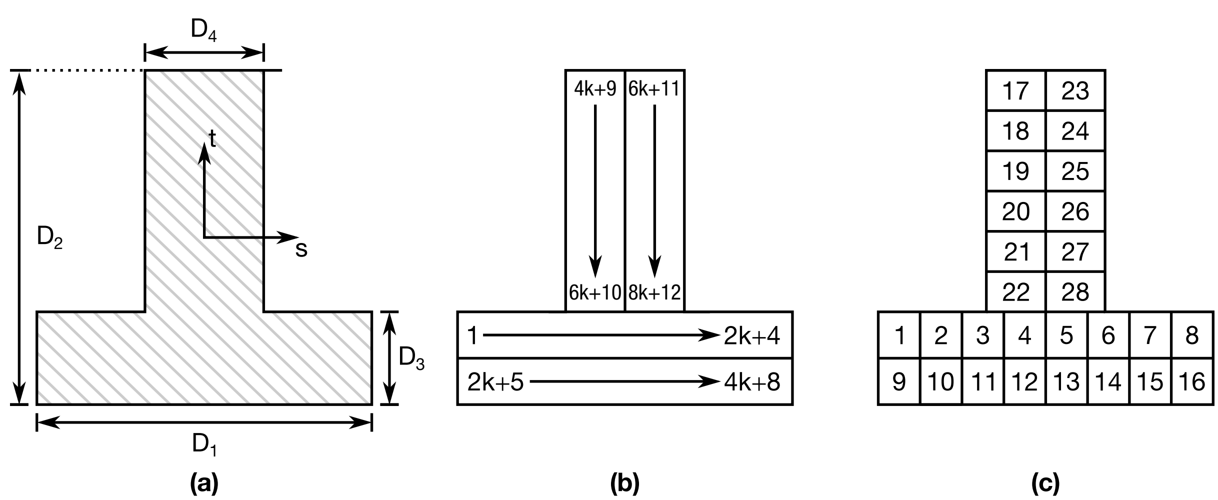


Figure 29-20. Type 18: T-Shape 3. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

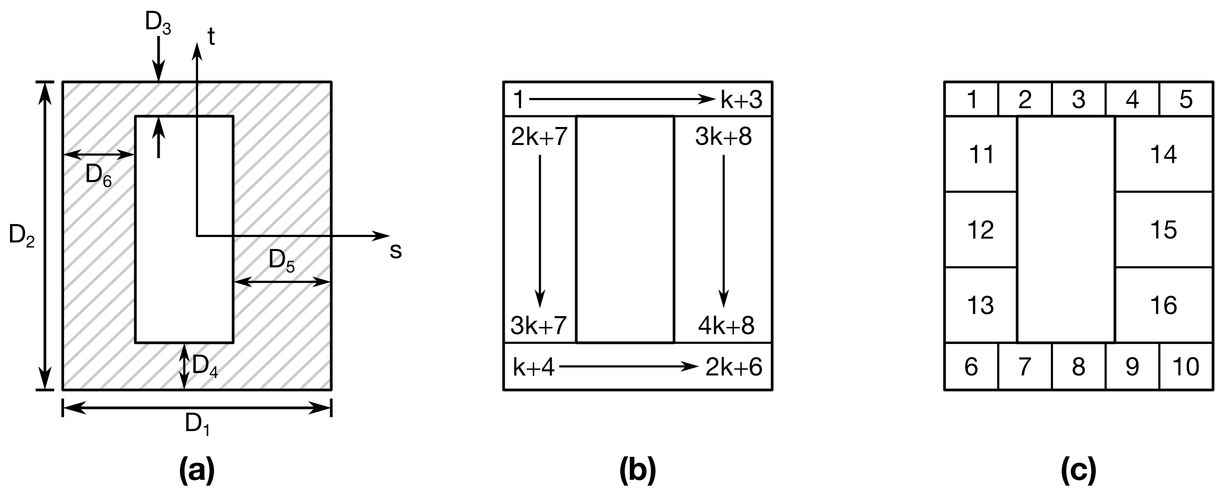


Figure 29-21. Type 19: Box Shape 2. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

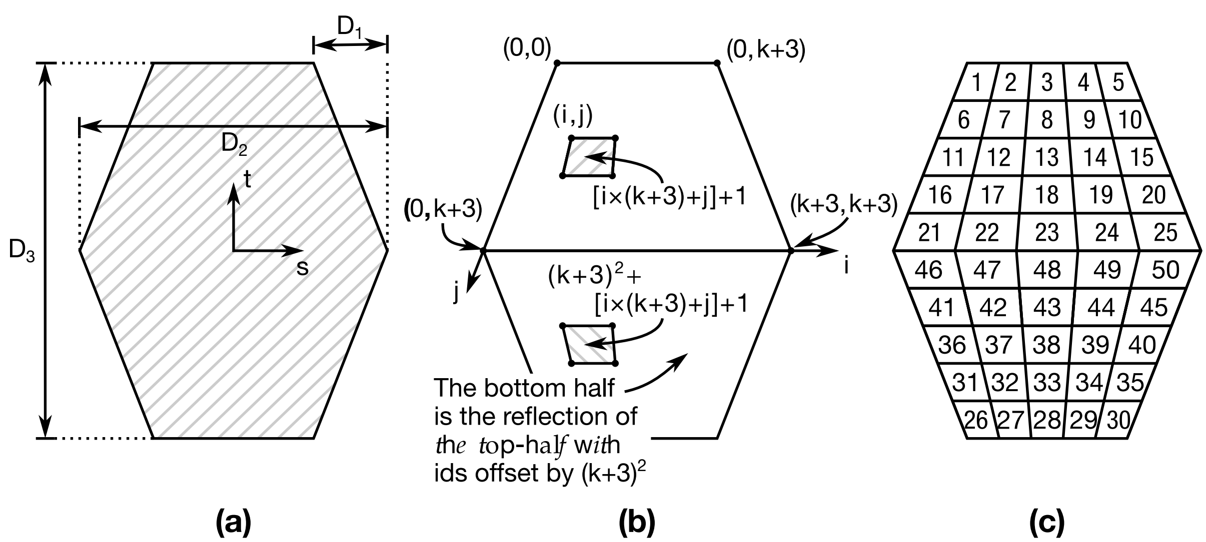


Figure 29-22. Type 20: Hexagon. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

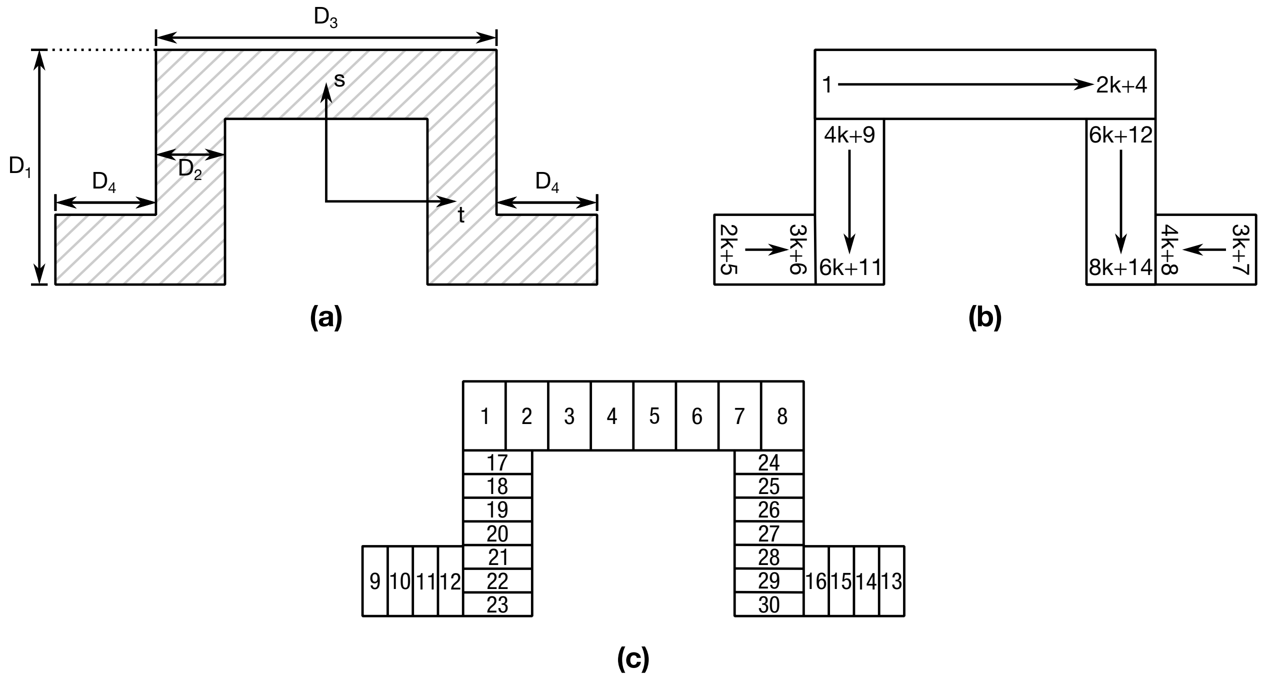


Figure 29-23. Type 21: Hat-Shape. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

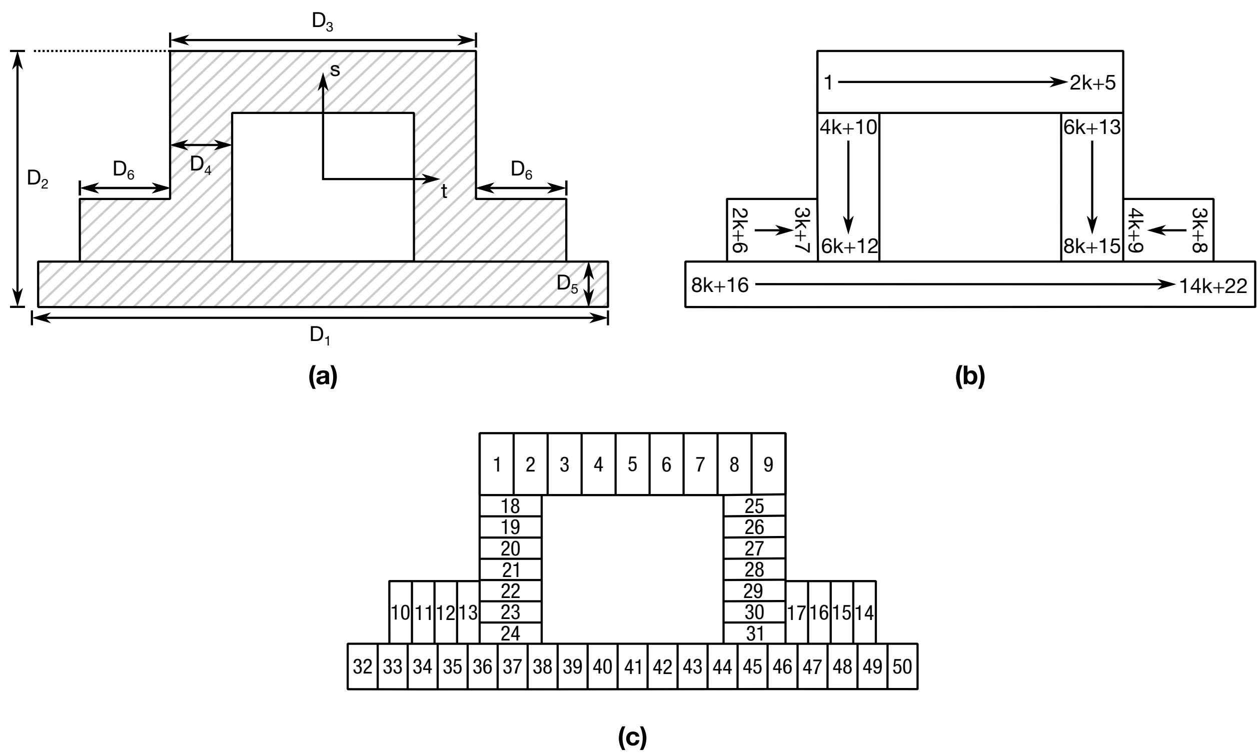


Figure 29-24. Type 22: Hat-Shape 2. (a) Cross section geometry. (b) Integration point numbering. (c) Example for k = 2.

*INTEGRATION_SHELL

Purpose: Define user defined through the thickness integration rules for the shell element. This option applies to three-dimensional shell elements with three or four nodes (*SECTION_SHELL types 1-11, ±16, 17, 18, 20, 21, 23-27, 30, 41, 42, and 101-105), to eight node thick shell types 1, 2, and 6 (*SECTION_TSHELL), and to all IGA shell types (*SECTION_IGA_SHELL). See *PART_COMPOSITE for a simpler alternative to *PART + *SECTION_SHELL + *INTEGRATION_SHELL.

Card 1	1	2	3	4	5	6	7	8
Variable	IRID	NIP	ESOP	FAILOPT				
Type	I	I	I	I				

Define NIP cards below if ESOP = 0.

Card 2	1	2	3	4	5	6	7	8
Variable	S	WF	PID					
Type	F	F	I					

VARIABLE	DESCRIPTION
IRID	Integration rule ID (IRID refers to IRID on *SECTION_SHELL card).
NIP	Number of integration points
ESOP	Equal spacing of integration points option: EQ.0: Integration points are defined below, EQ.1: Integration points are equally spaced through thickness such that the shell is subdivided into NIP layers of equal thickness.
FAILOPT	Treatment of failure when mixing different constitutive types, which do and do not include failure models, through the shell thickness. For example, consider the case where a linear viscoelastic material model, which does not have a failure option, is mixed with a composite model, which does have a failure option. Note: If the failure option includes failure based on the time step size of

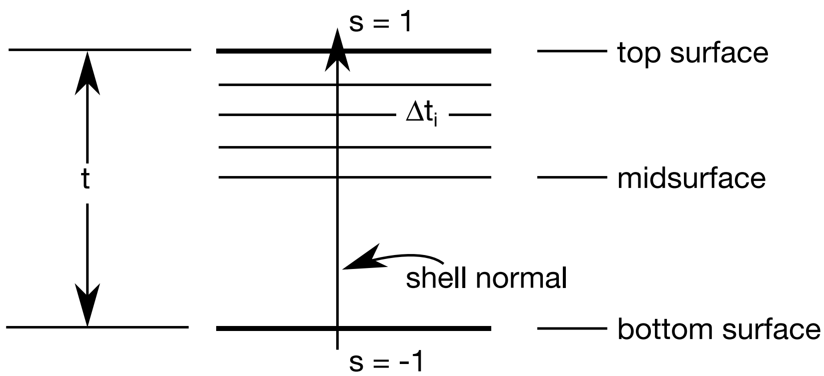


Figure 29-25. For the user defined shell integration rule the ordering of the integration points is arbitrary.

VARIABLE	DESCRIPTION
	the element, element deletion will occur regardless of the value of FAILOPT. EQ.0: Element is deleted when the layers which include failure, fail. EQ.1: Element failure cannot occur since some layers do not have a failure option.
S	Coordinate of integration point in range -1 to 1.
WF	Weighting factor. This is typically the thickness associated with the integration point divided by actual shell thickness, that is, the weighting factor for the i^{th} integration point = $\Delta t_i / t$ as seen in Figure 29-25.
PID	Optional part ID if different from the PID specified on the element card. The average mass density for the shell element is based on a weighted average of the density of each layer that is used through the thickness. When modifying the constitutive constants through the thickness, it is often necessary to defined unique part IDs without elements that are referenced only by the user integration rule. These additional part IDs only provide a density and constitutive constants with local material axes (if used) and orientation angles taken from the PID referenced on the element card. In defining a PID for an integration point, it is okay to reference a solid element PID. The material type through the thickness can vary.