SUPPLEMENTAL DATA

The following figures plot contours of $R_{Q,S}$ for a pile radius of $r_p = 0.4\,\text{m}$, at-rest earth pressure coefficient $K_0 = 0.5$, cohesion intercept $c' = 0$, Poisson's ratio $\nu = 0.2$, critical state friction angle $\phi'_{cv} = 25°$, 30°, 35°, relative density $I_d = 0.4$, 0.7, 1.0, and tunnel radius $r_t = 1$, 3, 5 m. Unit weight of the soil was determined using the value of relative density alongside maximum and minimum void ratios of 0.97 and 0.64, respectively, and a specific gravity of 2.67.

Table 1 provides links to the design charts for displacement piles. Table 2 provides links to the design charts for non-displacement piles that mobilize shaft capacity only. Table 3 provides links to the design charts for non-displacement piles that mobilize shaft and base capacity. The results for the non-displacement piles that mobilize shaft and base capacity are dependant on the relative proportions of shaft and base capacity. The results presented here relate to the relative capacities indicated in Figure 8 of the main paper. Tables 1 to 3 relate to the case of dry soils.

Tables 4 and 5 provide links to the design charts for displacement and non-displacement (no base capacity) piles, respectively, for the case of saturated soil. Three water table depths z_w are considered: $z_w \geq z_t$ (at tunnel depth, equivalent to dry case), $z_w = z_p$ (at depth of pile tip), and $z_w = 0$ (at ground surface).

TABLE 1. Design charts for displacement piles - no water

Tunnel radius r_t	Relative density I_d	Friction angle ϕ'_{cv}	Figure
(m)	-	$^\circ$	
1	0.4;0.7;1.0	25	1
3	0.4;0.7;1.0	25	2
5	0.4;0.7;1.0	25	3
1	0.4;0.7;1.0	30	4
3	0.4;0.7;1.0	30	5
5	0.4;0.7;1.0	30	6
1	0.4;0.7;1.0	35	7
3	0.4;0.7;1.0	35	8
5	0.4;0.7;1.0	35	9

TABLE 2. Design charts for non-displacement piles with no base capacity - no water

Tunnel radius r_t	Relative density I_d	Friction angle ϕ'_{cv}	Figure
(m)	-	$^\circ$	
1	0.4;0.7;1.0	25	10
3	0.4;0.7;1.0	25	11
5	0.4;0.7;1.0	25	12
1	0.4;0.7;1.0	30	13
3	0.4;0.7;1.0	30	14
5	0.4;0.7;1.0	30	15
1	0.4;0.7;1.0	35	16
3	0.4;0.7;1.0	35	17
5	0.4;0.7;1.0	35	18

TABLE 3. Design charts for non-displacement piles with shaft and base capacity - no water

Tunnel radius r_t	Relative density I_d	Friction angle ϕ'_{cv}	Figure
(m)	-	°	
1	0.4;0.7;1.0	25	19
3	0.4;0.7;1.0	25	20
5	0.4;0.7;1.0	25	21
1	0.4;0.7;1.0	30	22
3	0.4;0.7;1.0	30	23
5	0.4;0.7;1.0	30	24
1	0.4;0.7;1.0	35	25
3	0.4;0.7;1.0	35	26
5	0.4;0.7;1.0	35	27

TABLE 4. Design charts for displacement piles - including water

Tunnel radius r_t	Relative density I_d	Friction angle ϕ_{cv}	Water table depth z_w	Figure
(m)	-	°		
1	0.4	25	z_t ; z_p ; 0	28
1	0.7	25	z_t ; z_p ; 0	29
1	1	25	z_t ; z_p ; 0	30
3	0.4	25	z_t ; z_p ; 0	31
3	0.7	25	z_t ; z_p ; 0	32
3	1	25	z_t ; z_p ; 0	33
5	0.4	25	z_t ; z_p ; 0	34
5	0.7	25	z_t ; z_p ; 0	35
5	1	25	z_t ; z_p ; 0	36
1	0.4	30	z_t ; z_p ; 0	37
1	0.7	30	z_t ; z_p ; 0	38
1	1	30	z_t ; z_p ; 0	39
3	0.4	30	z_t ; z_p ; 0	40
3	0.7	30	z_t ; z_p ; 0	41
3	1	30	z_t ; z_p ; 0	42
5	0.4	30	z_t ; z_p ; 0	43
5	0.7	30	z_t ; z_p ; 0	44
5	1	30	z_t ; z_p ; 0	45
1	0.4	35	z_t ; z_p ; 0	46
1	0.7	35	z_t ; z_p ; 0	47
1	1	35	z_t ; z_p ; 0	48
3	0.4	35	z_t ; z_p ; 0	49
3	0.7	35	z_t ; z_p ; 0	50
3	1	35	z_t ; z_p ; 0	51
5	0.4	35	z_t ; z_p ; 0	52
5	0.7	35	z_t ; z_p ; 0	53
5	1	35	z_t ; z_p ; 0	54

TABLE 5. Design charts for non-displacement piles (no base capacity) - including water

Tunnel radius r_t	Relative density I_d	Friction angle ϕ_{cv}	Water table depth z_w	Figure
(m)	-	°		
1	0.4	25	z_t ; z_p ; 0	55
1	0.7	25	z_t ; z_p ; 0	56
1	1	25	z_t ; z_p ; 0	57
3	0.4	25	z_t ; z_p ; 0	58
3	0.7	25	z_t ; z_p ; 0	59
3	1	25	z_t ; z_p ; 0	60
5	0.4	25	z_t ; z_p ; 0	61
5	0.7	25	z_t ; z_p ; 0	62
5	1	25	z_t ; z_p ; 0	63
1	0.4	30	z_t ; z_p ; 0	64
1	0.7	30	z_t ; z_p ; 0	65
1	1	30	z_t ; z_p ; 0	66
3	0.4	30	z_t ; z_p ; 0	67
3	0.7	30	z_t ; z_p ; 0	68
3	1	30	z_t ; z_p ; 0	69
5	0.4	30	z_t ; z_p ; 0	70
5	0.7	30	z_t ; z_p ; 0	71
5	1	30	z_t ; z_p ; 0	72
1	0.4	35	z_t ; z_p ; 0	73
1	0.7	35	z_t ; z_p ; 0	74
1	1	35	z_t ; z_p ; 0	75
3	0.4	35	z_t ; z_p ; 0	76
3	0.7	35	z_t ; z_p ; 0	77
3	1	35	z_t ; z_p ; 0	78
5	0.4	35	z_t ; z_p ; 0	79
5	0.7	35	z_t ; z_p ; 0	80
5	1	35	z_t ; z_p ; 0	81

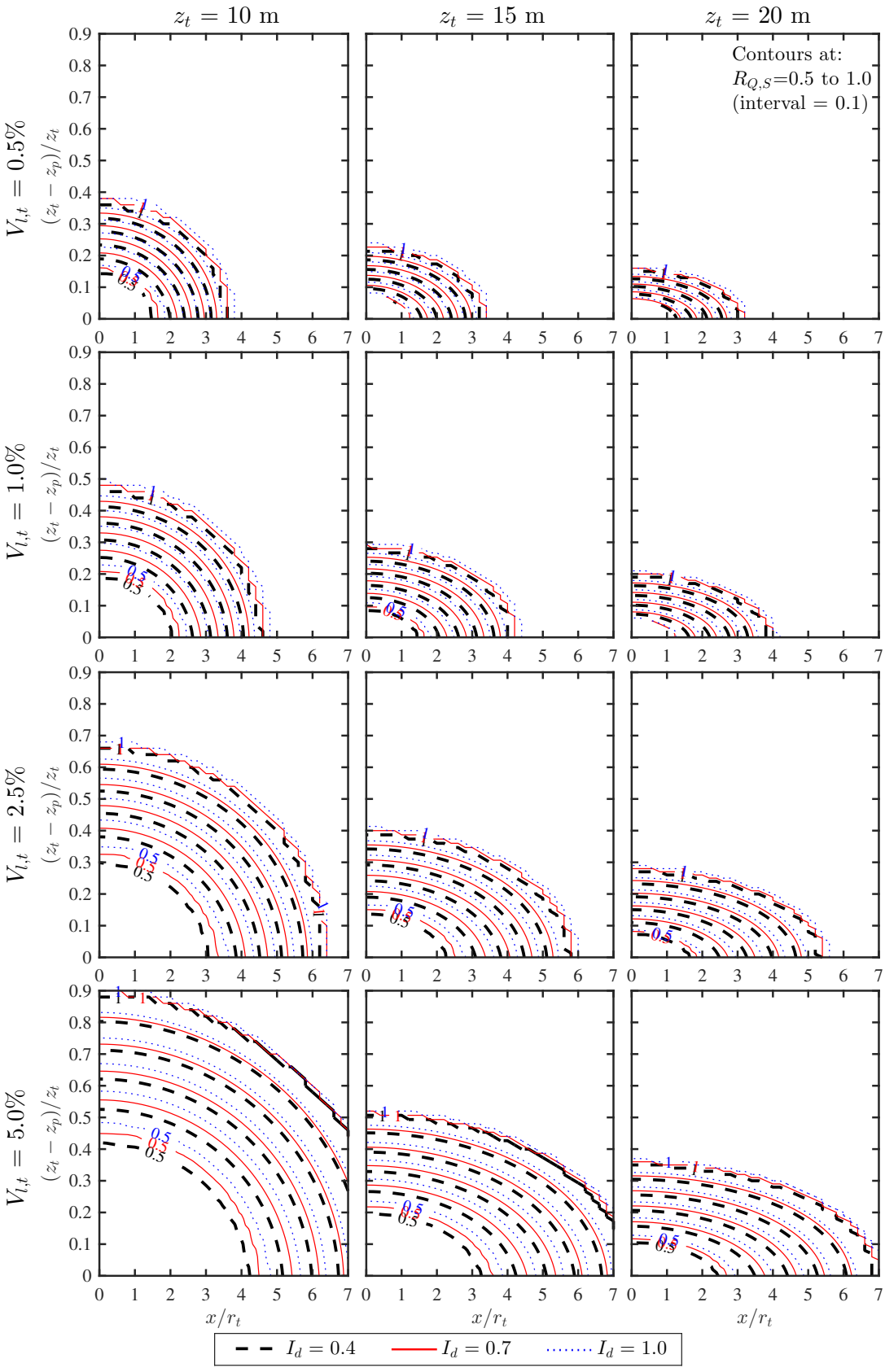

FIG. 1. Contour of $R_{Q,S}$ for displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

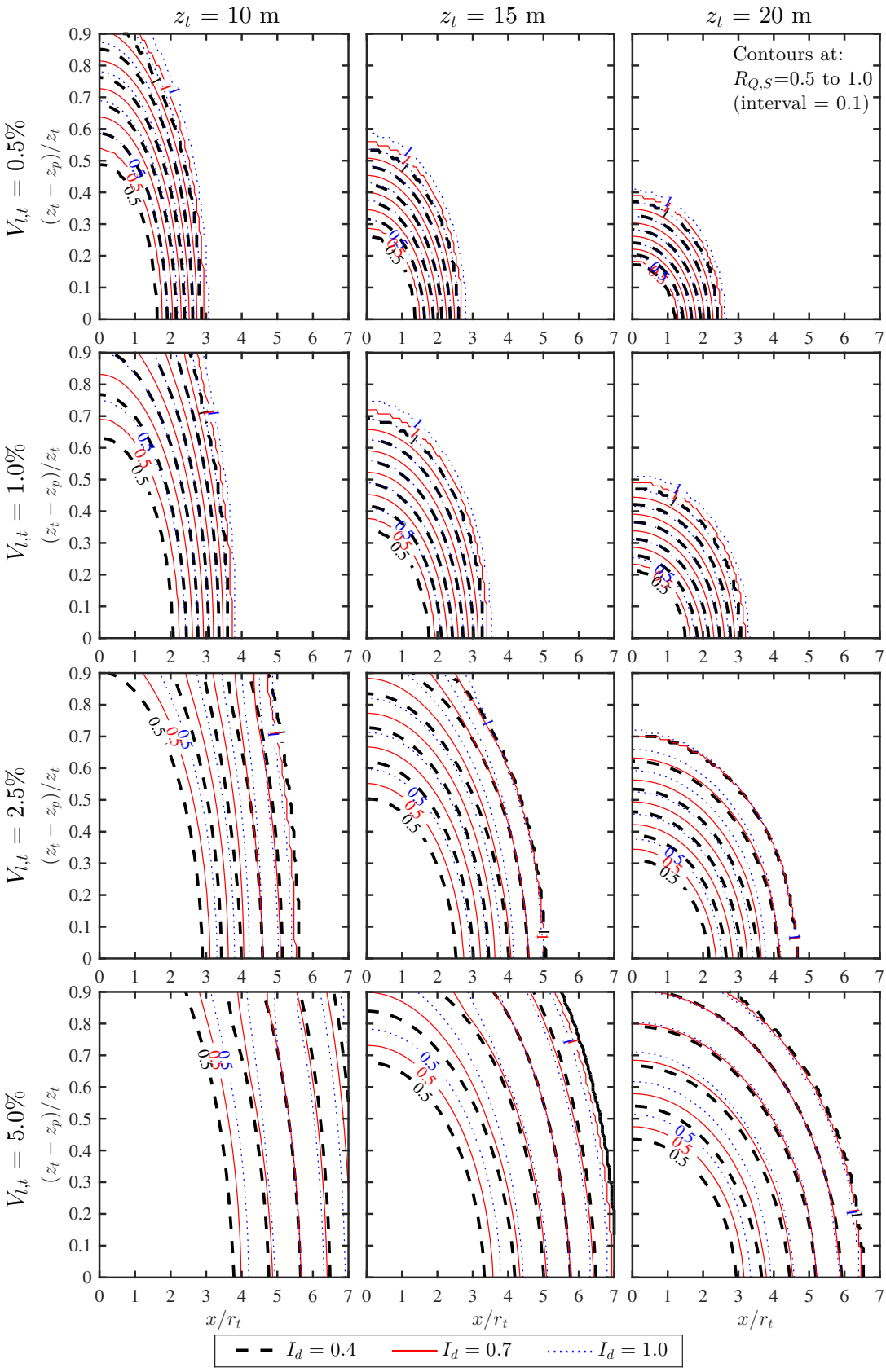

FIG. 2. Contour of $R_{Q,S}$ for displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

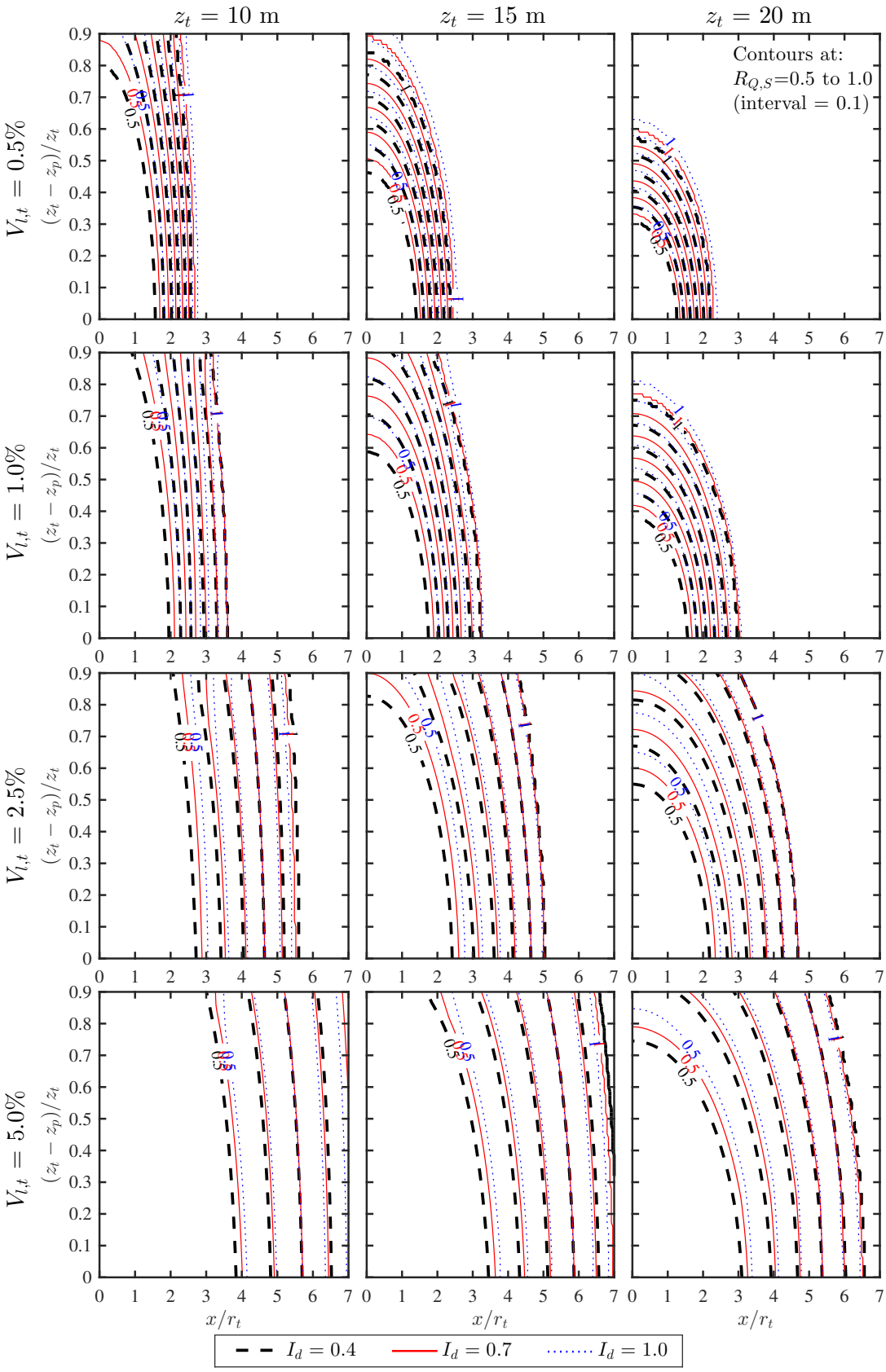

FIG. 3. Contour of $R_{Q,S}$ for displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

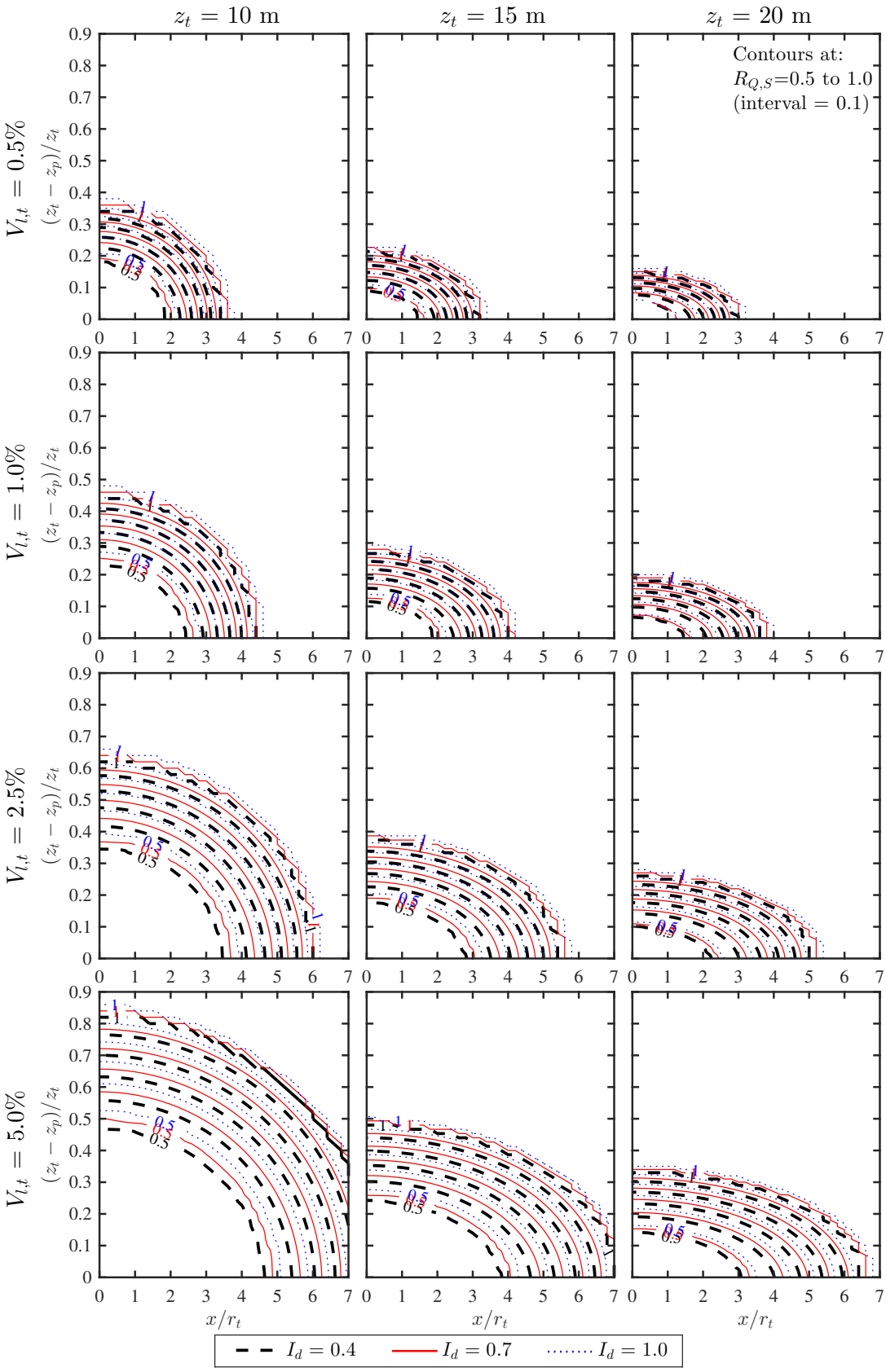

FIG. 4. Contour of $R_{Q,S}$ for displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

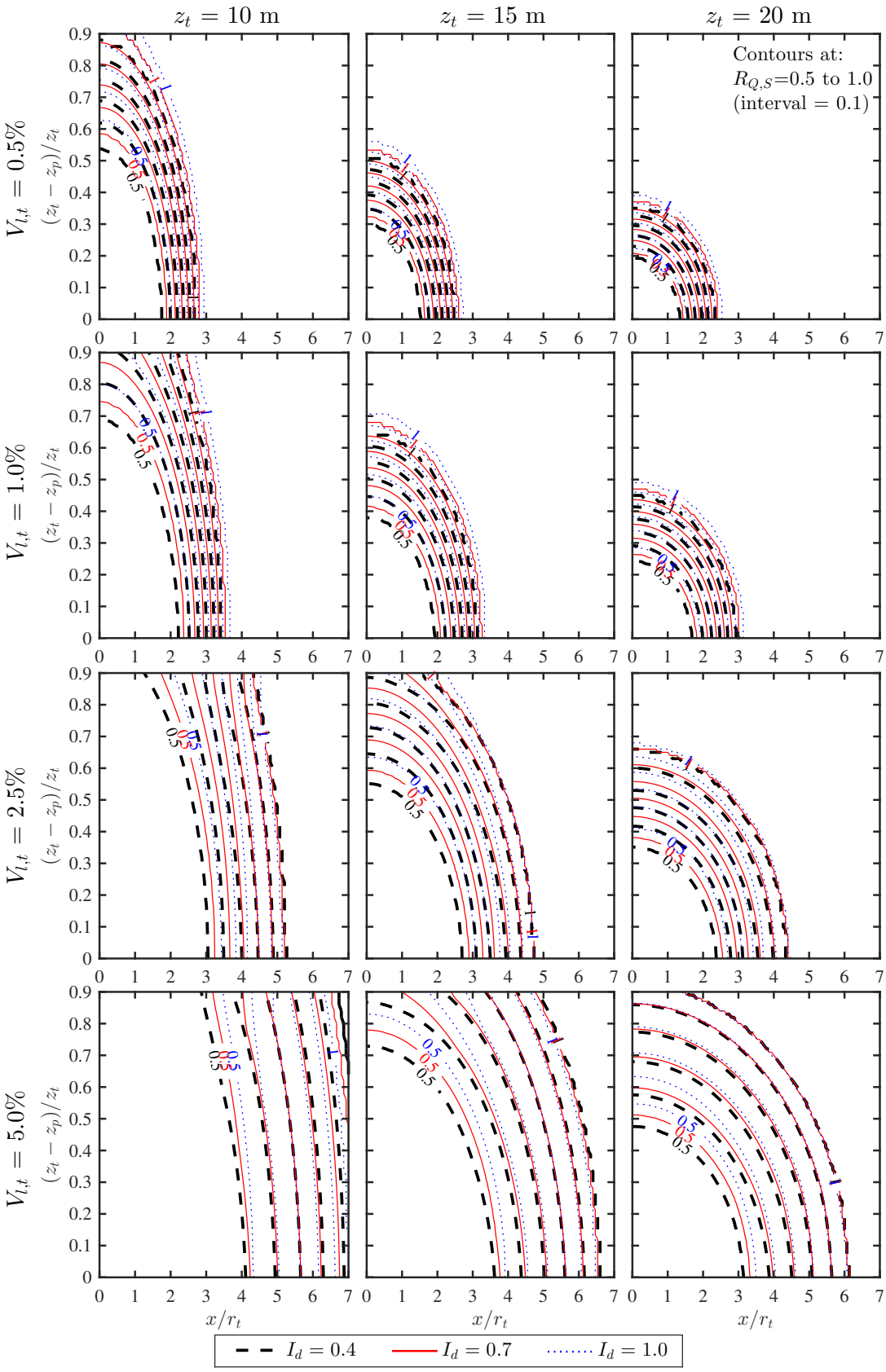

FIG. 5. Contour of $R_{Q,S}$ for displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

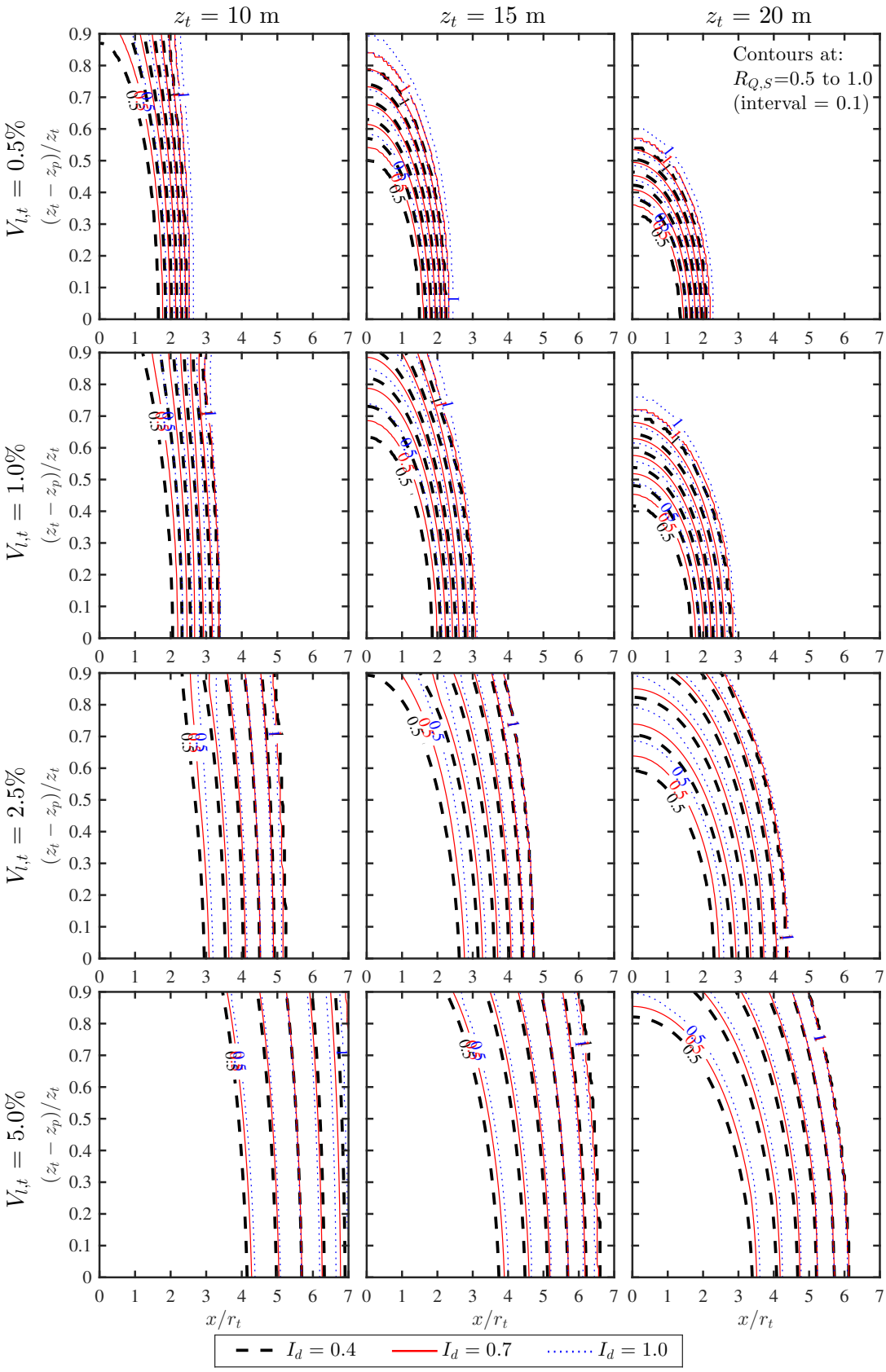

FIG. 6. Contour of $R_{Q,S}$ for displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

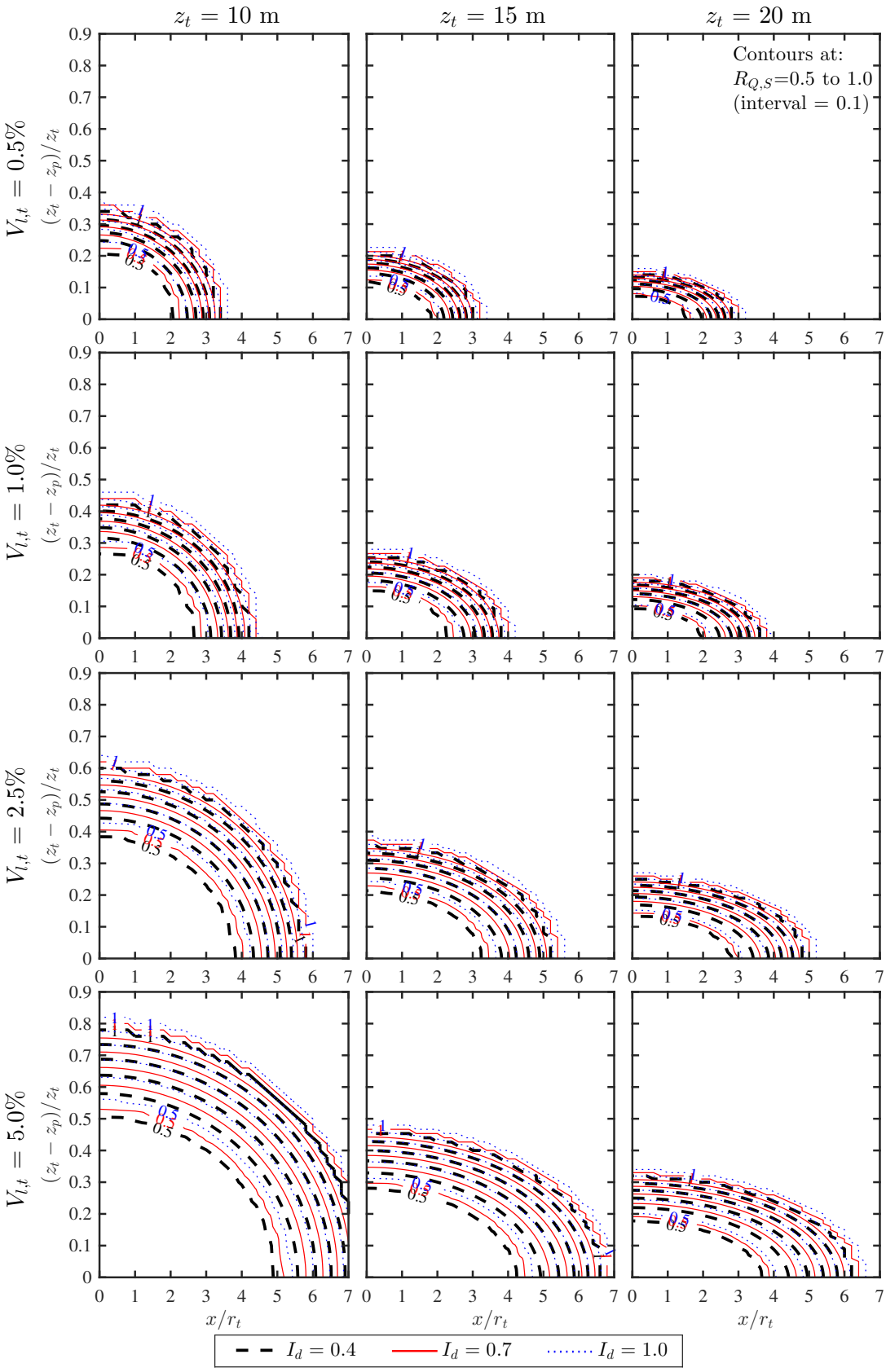

FIG. 7. Contour of $R_{Q,S}$ for displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

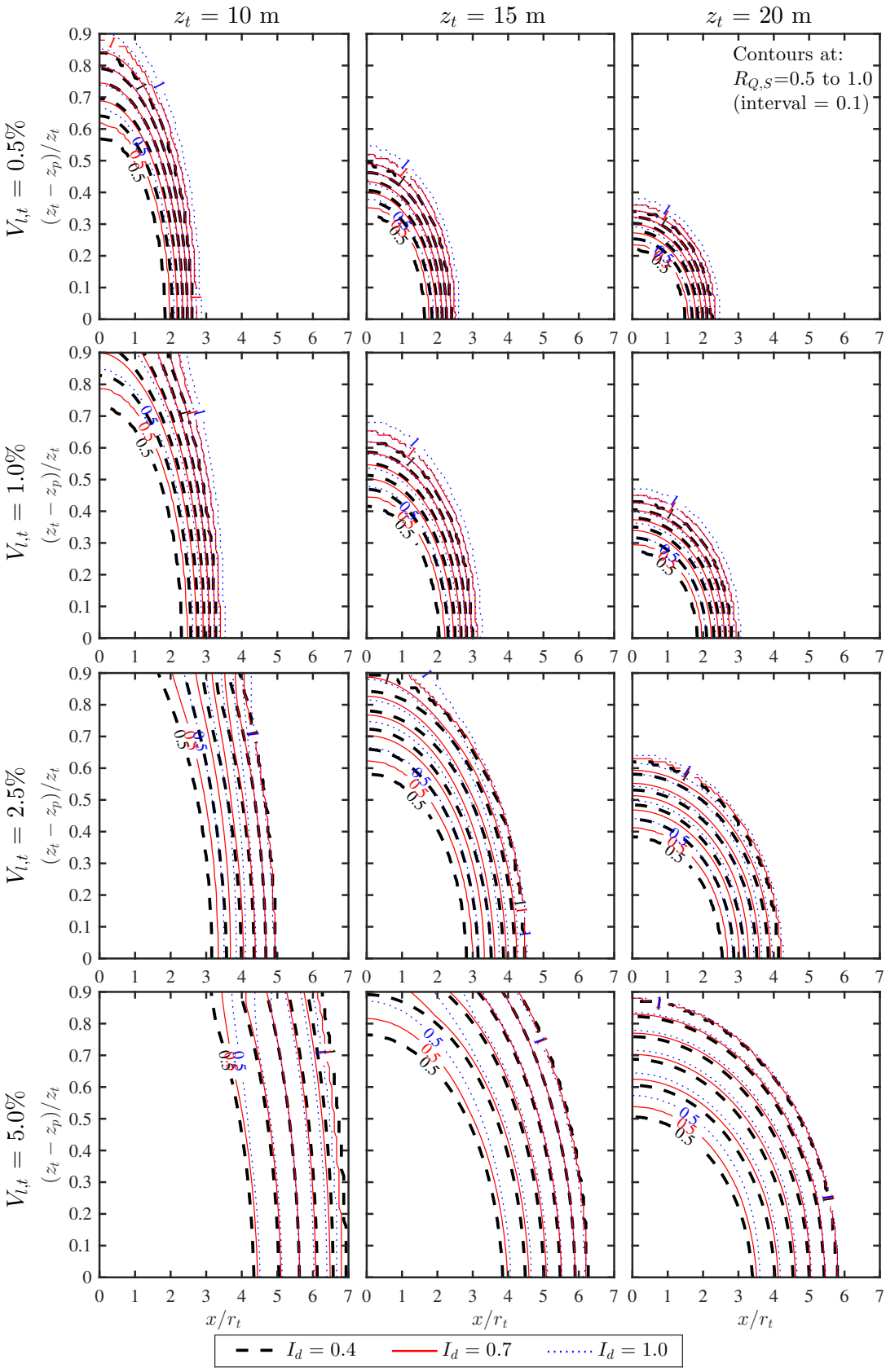

FIG. 8. Contour of $R_{Q,S}$ for displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

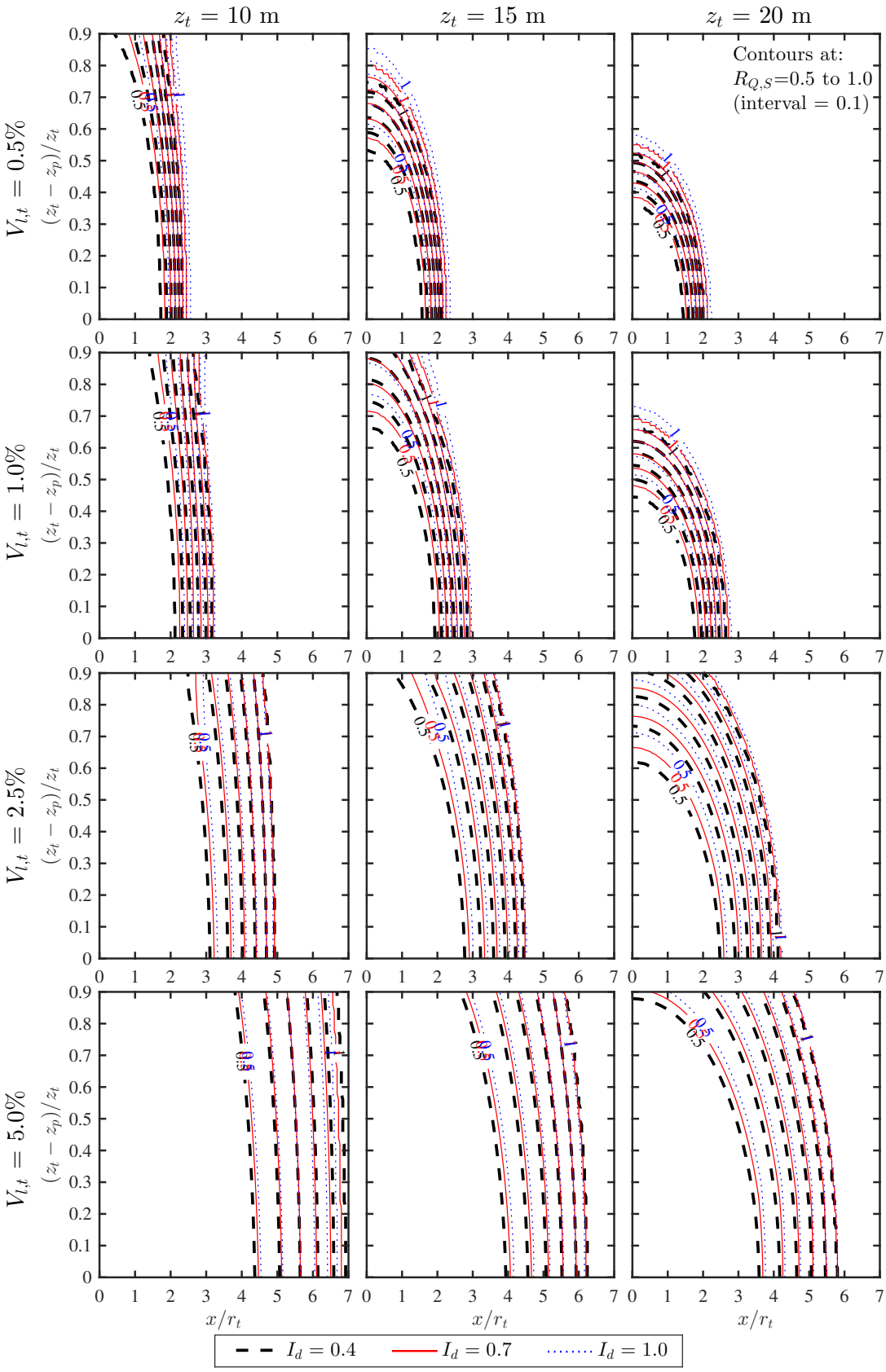

FIG. 9. Contour of $R_{Q,S}$ for displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

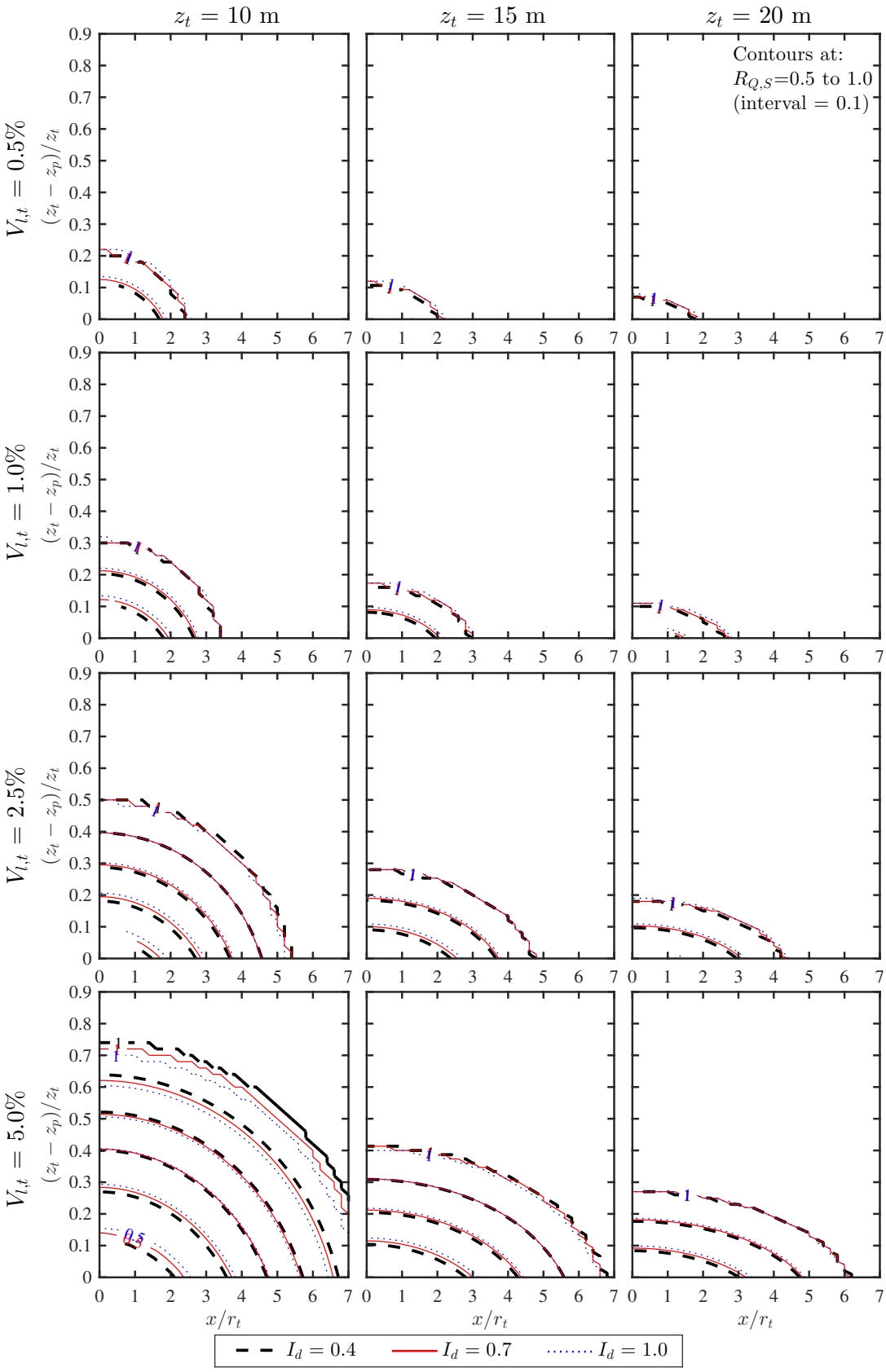

FIG. 10. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

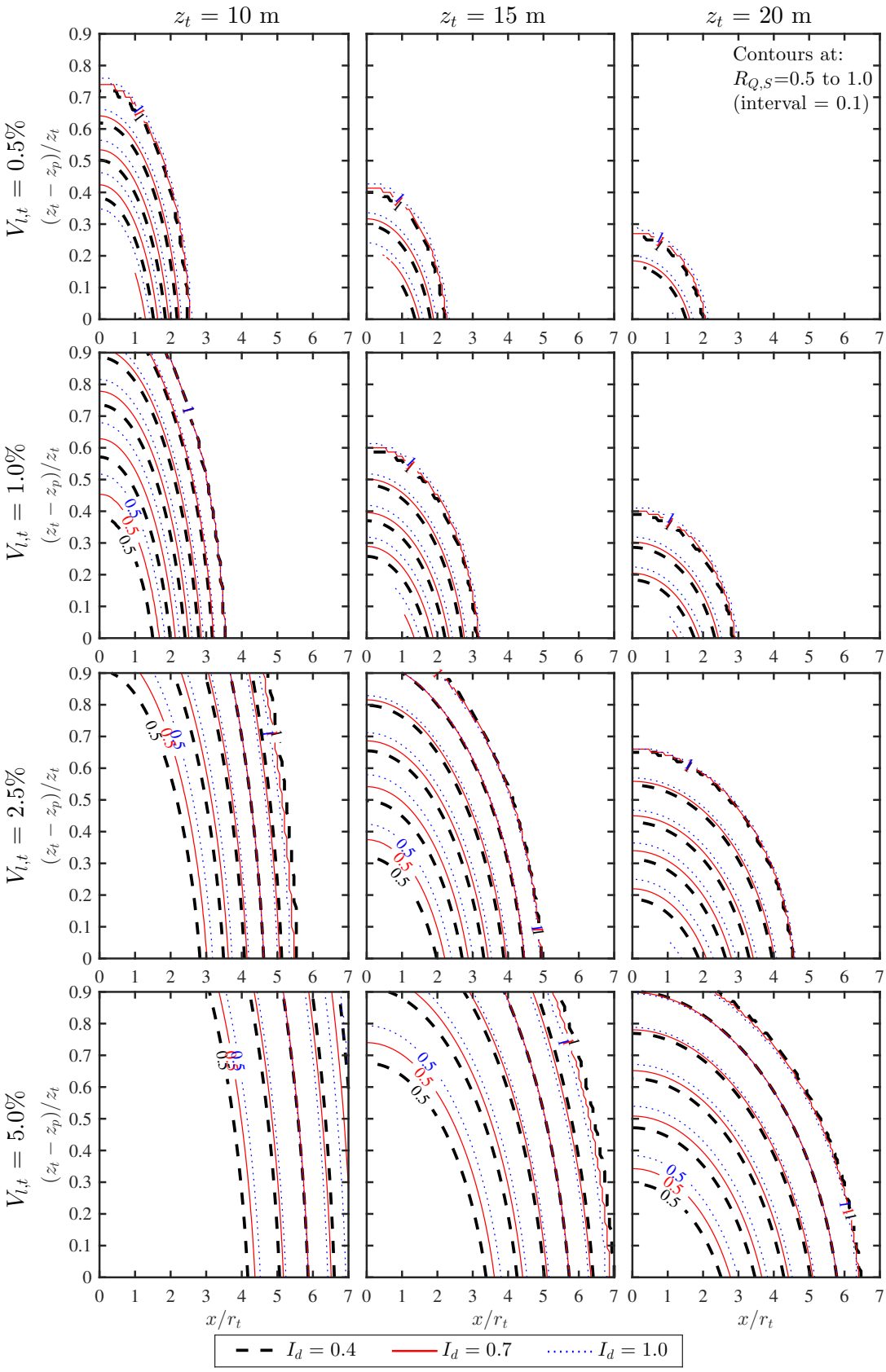

FIG. 11. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

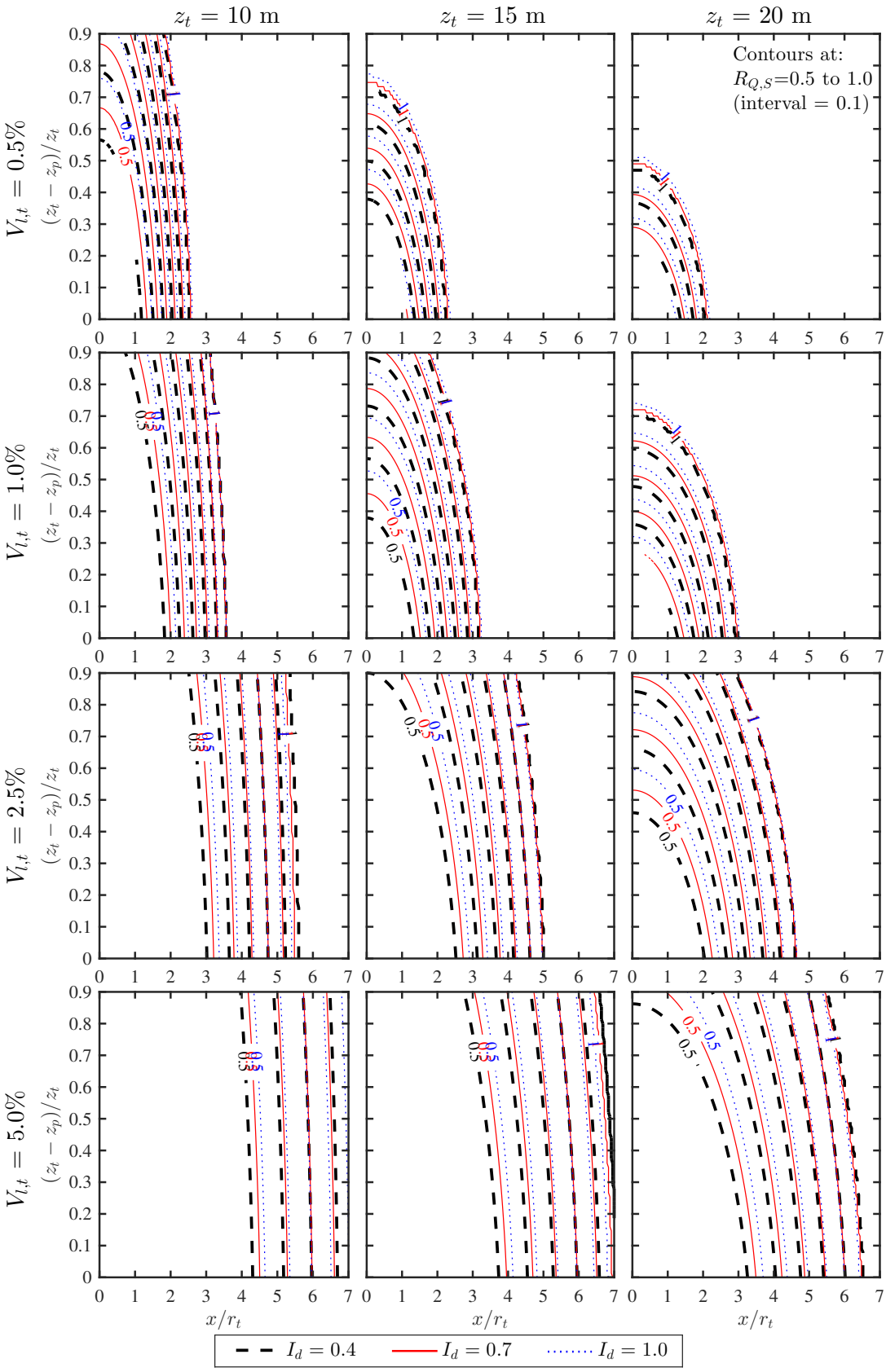

FIG. 12. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

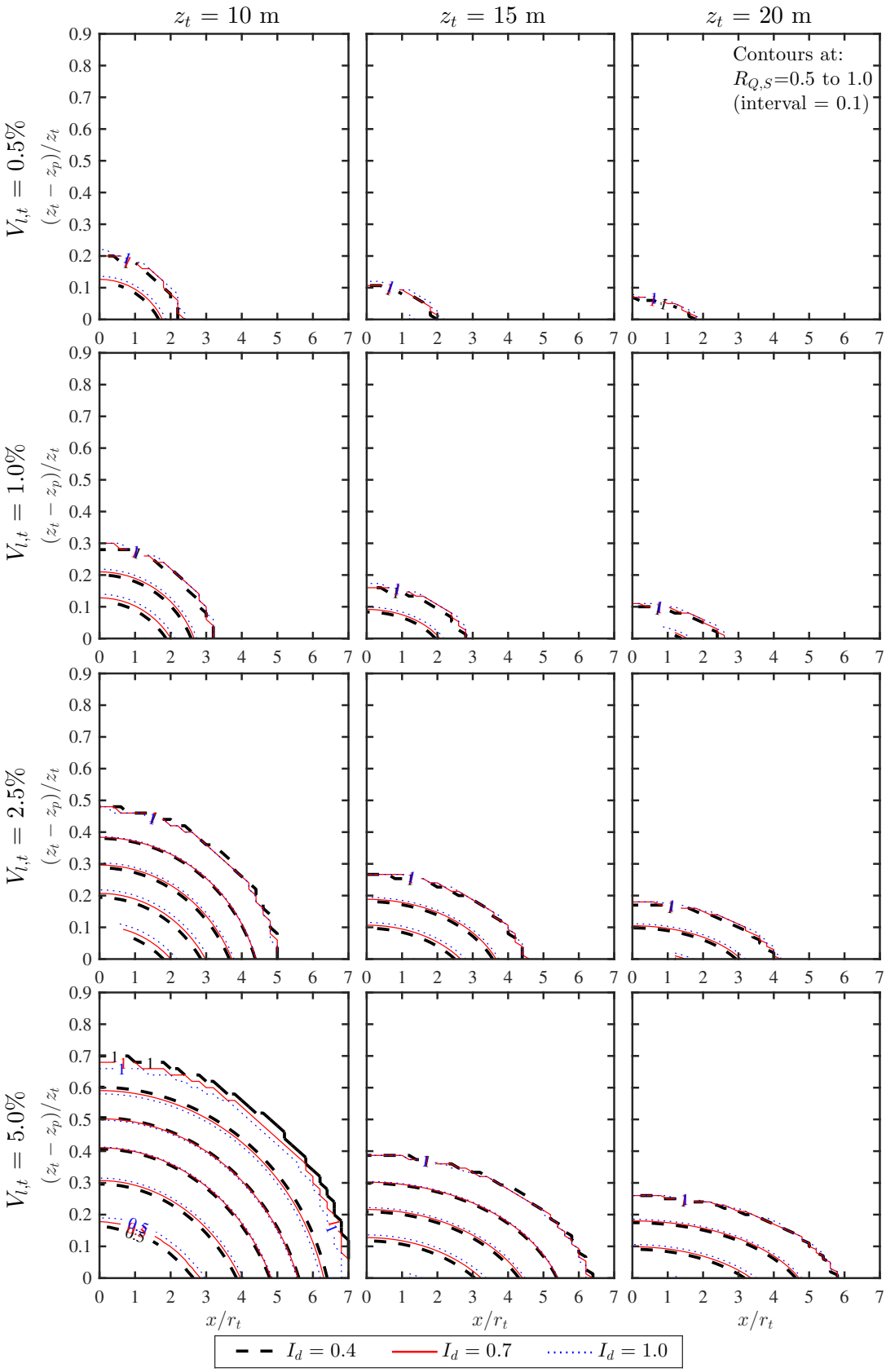

FIG. 13. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

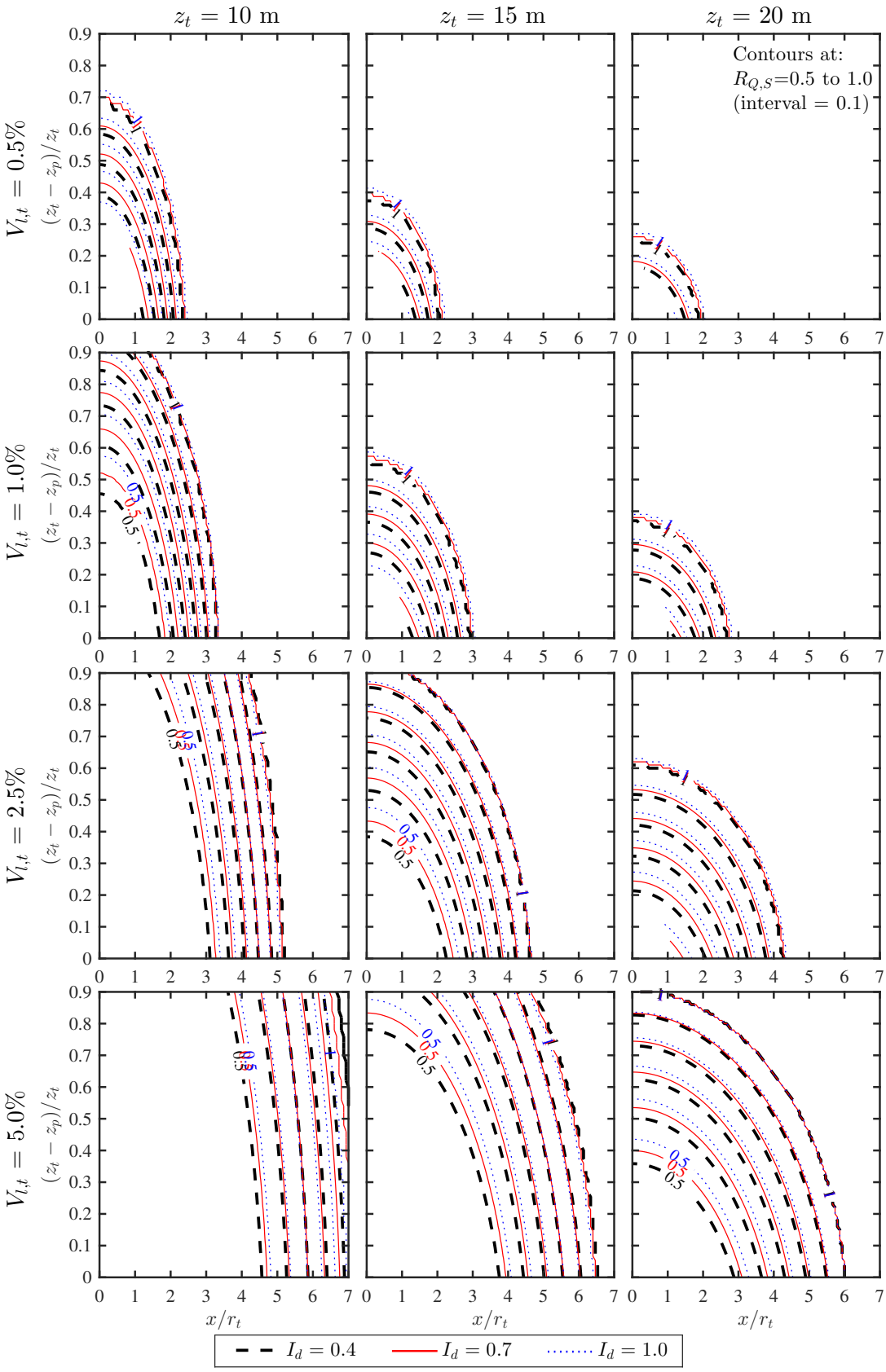

FIG. 14. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

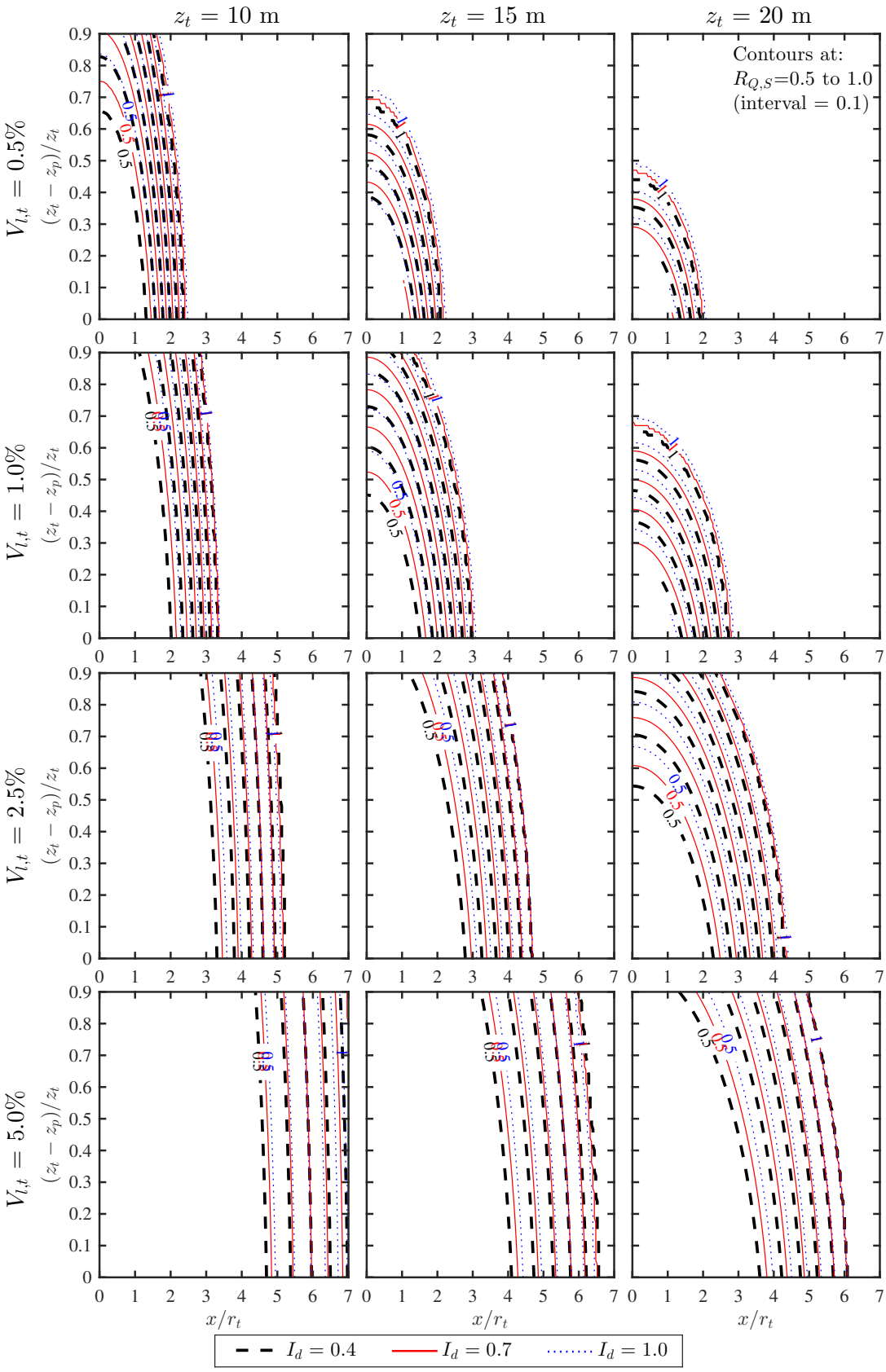

FIG. 15. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

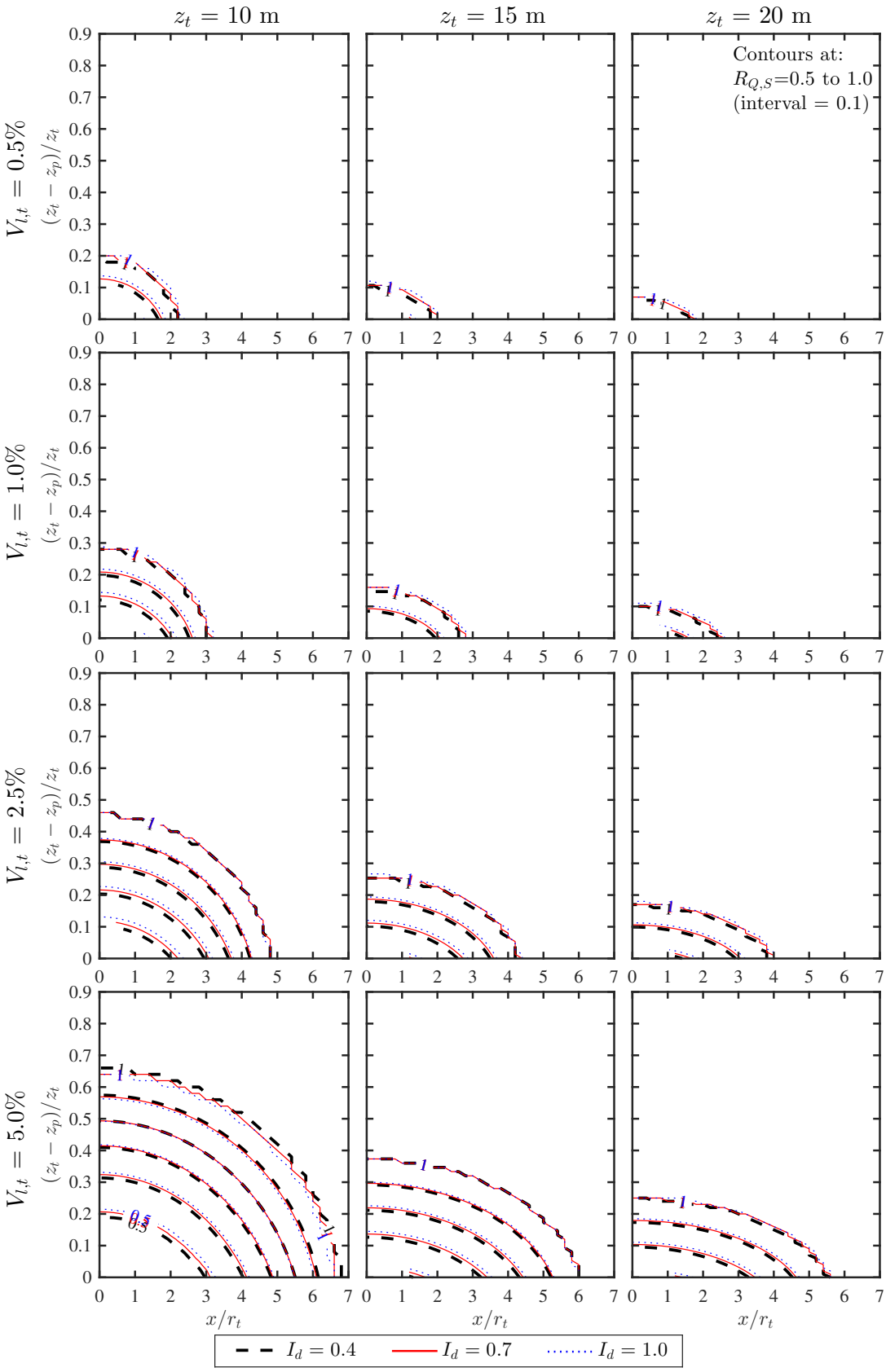

FIG. 16. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

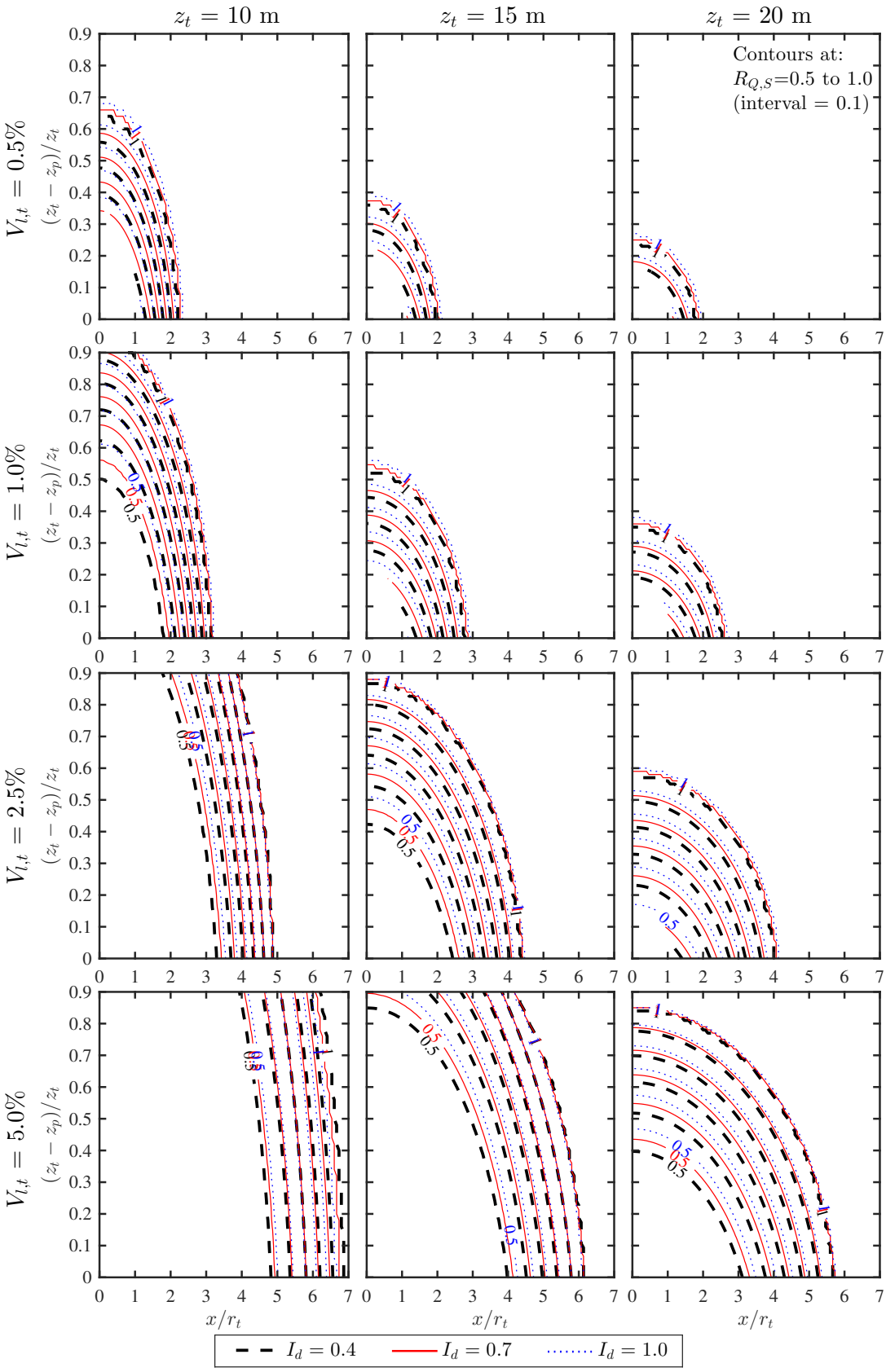

FIG. 17. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

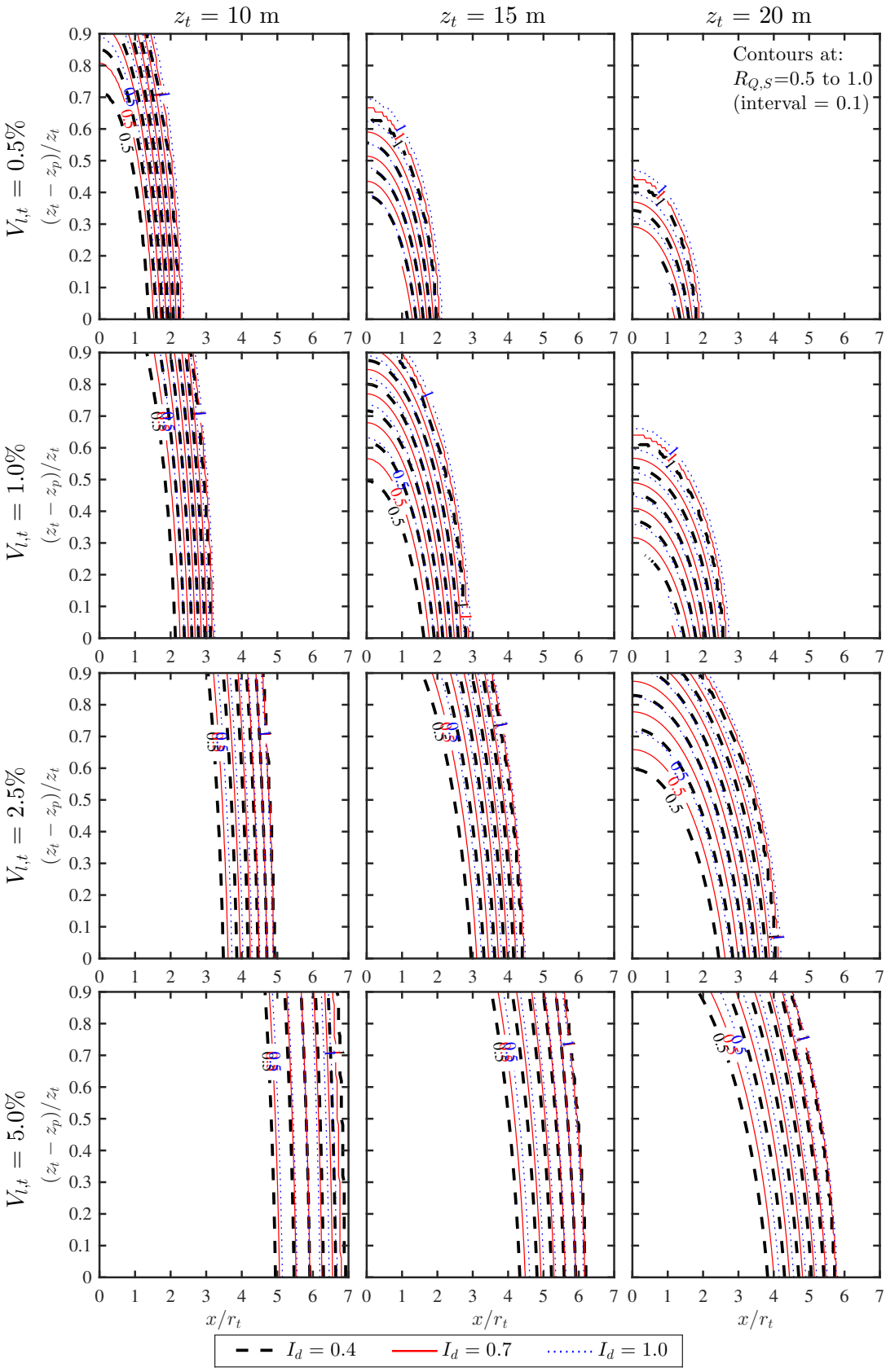

FIG. 18. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

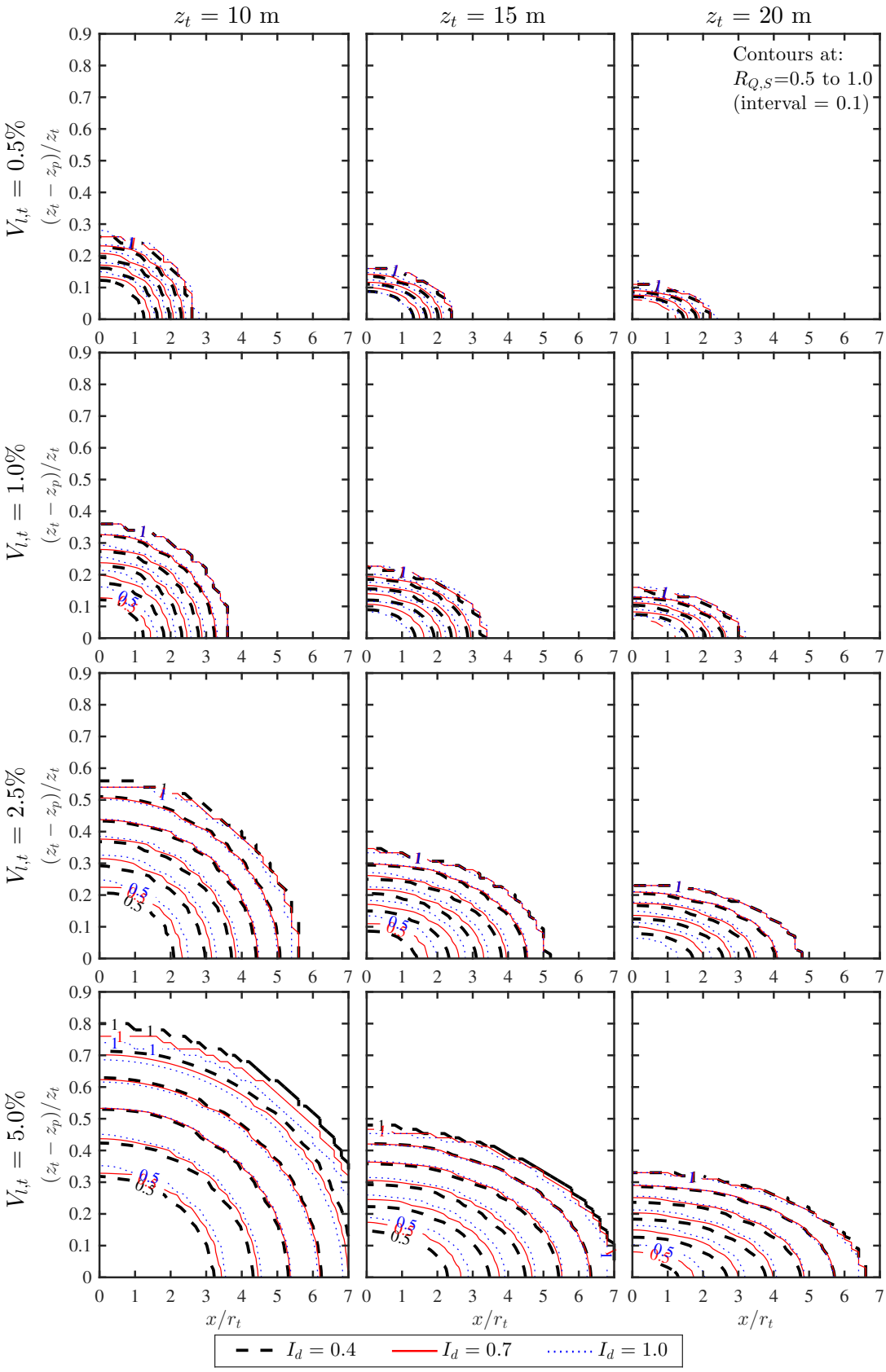

FIG. 19. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

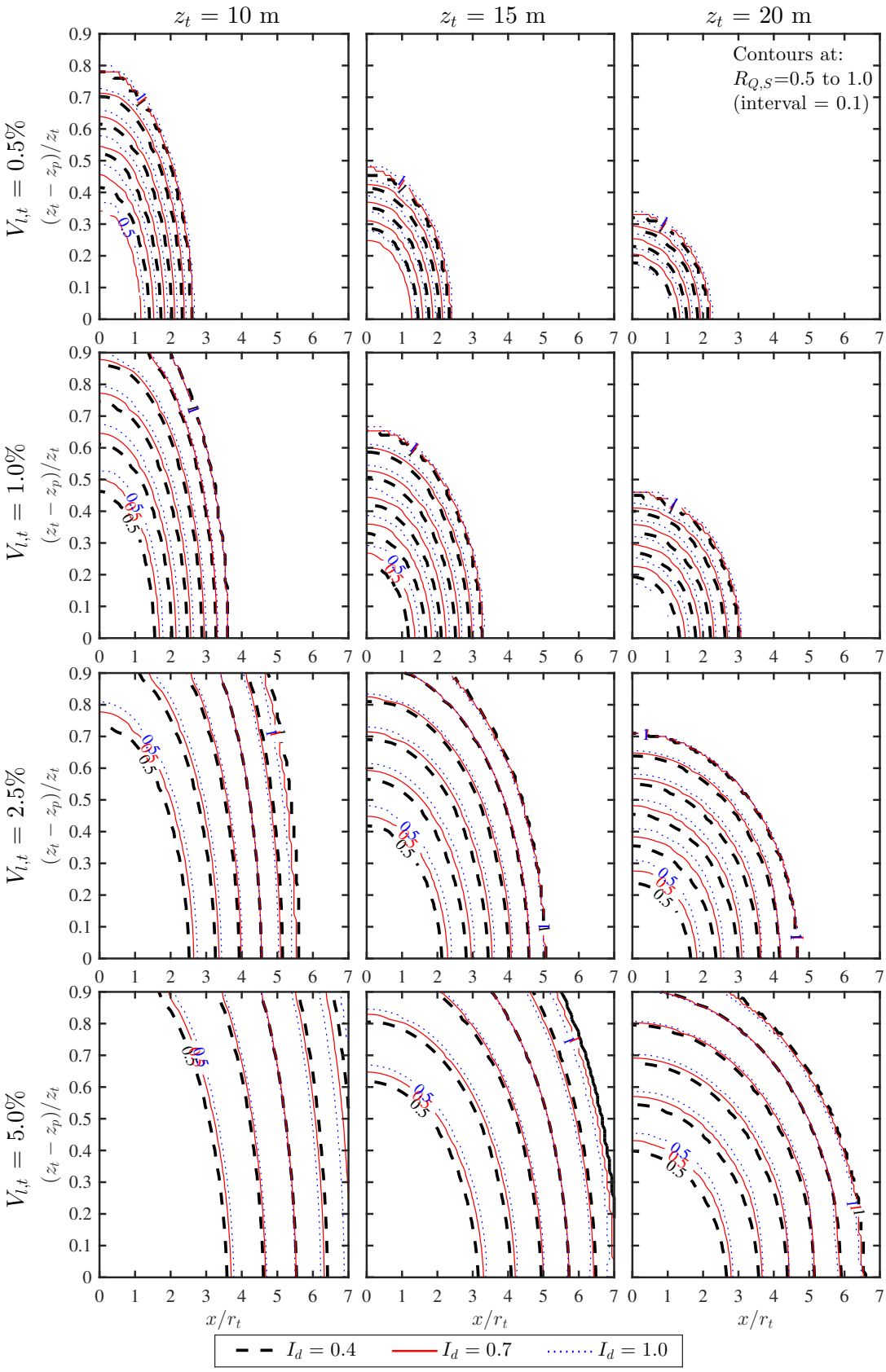

FIG. 20. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

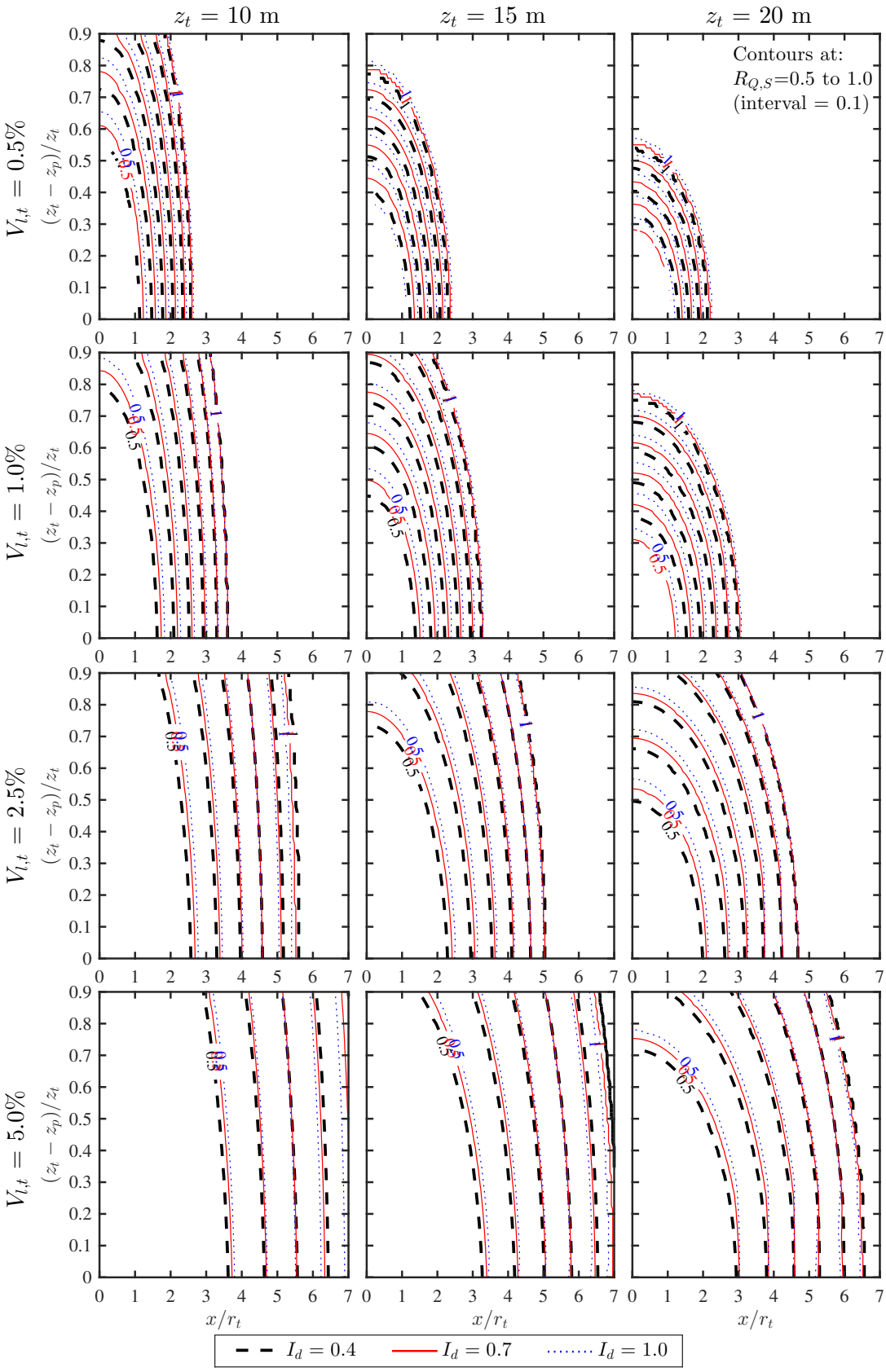

FIG. 21. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=25°

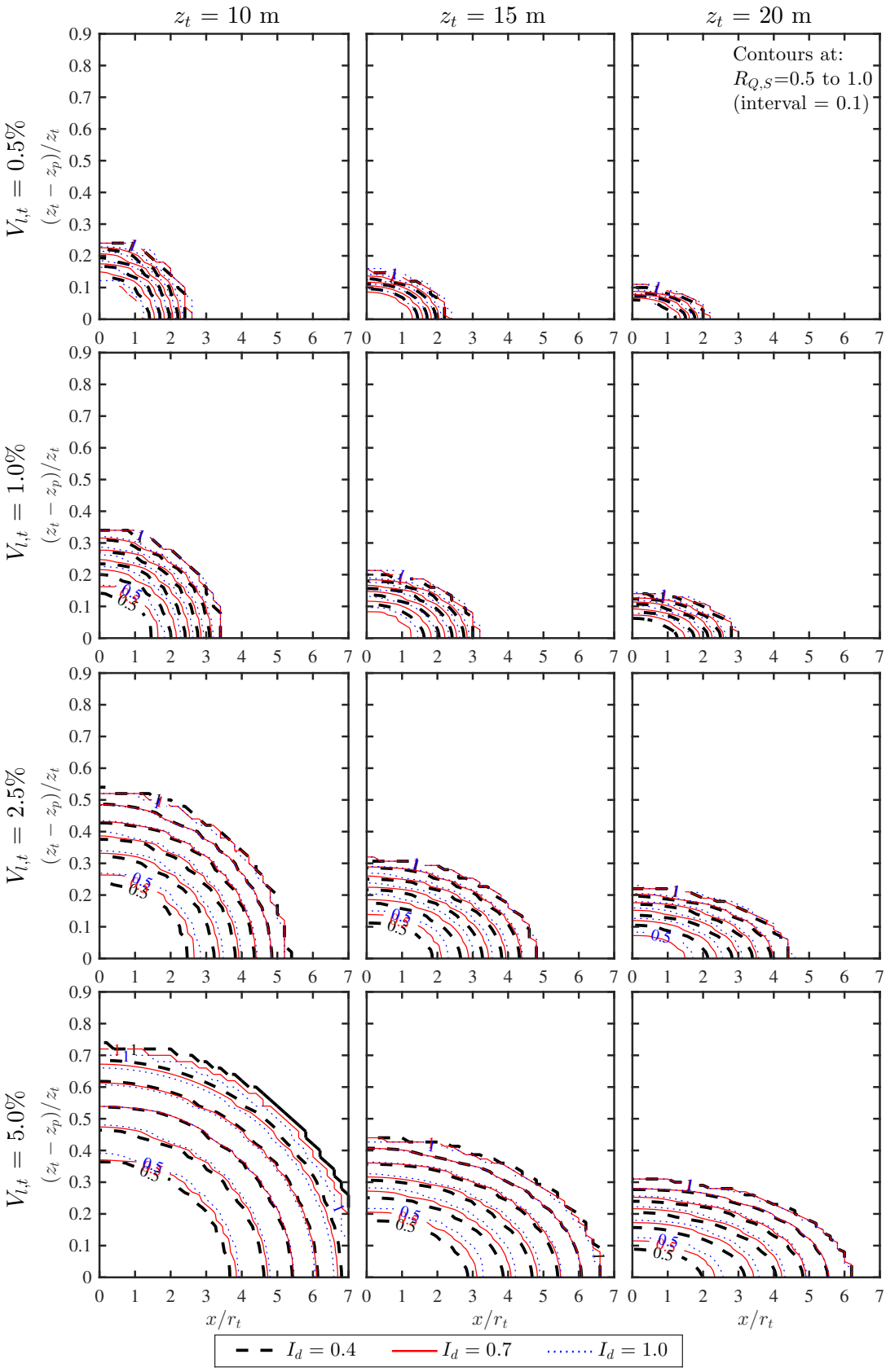

FIG. 22. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

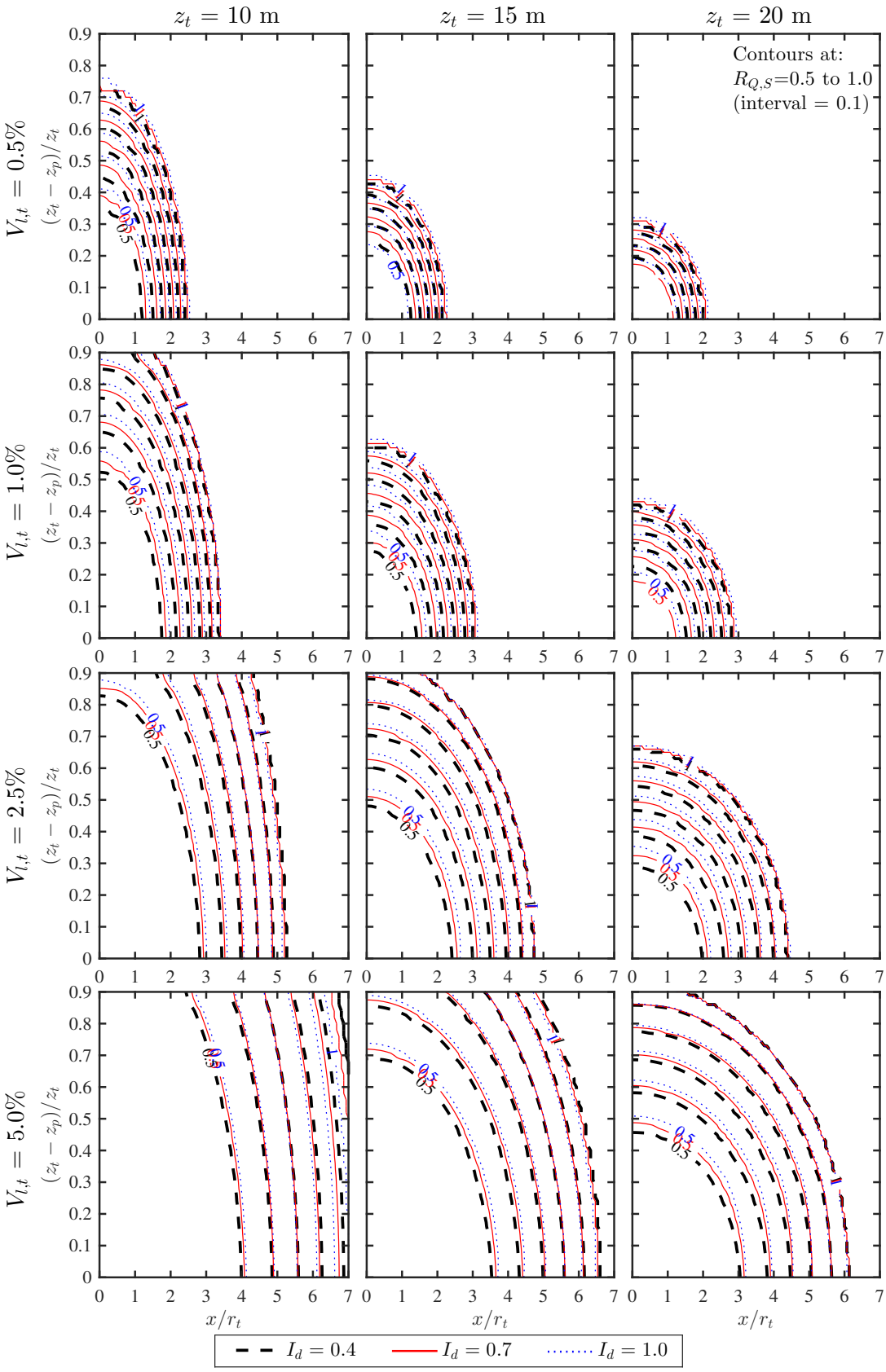

FIG. 23. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

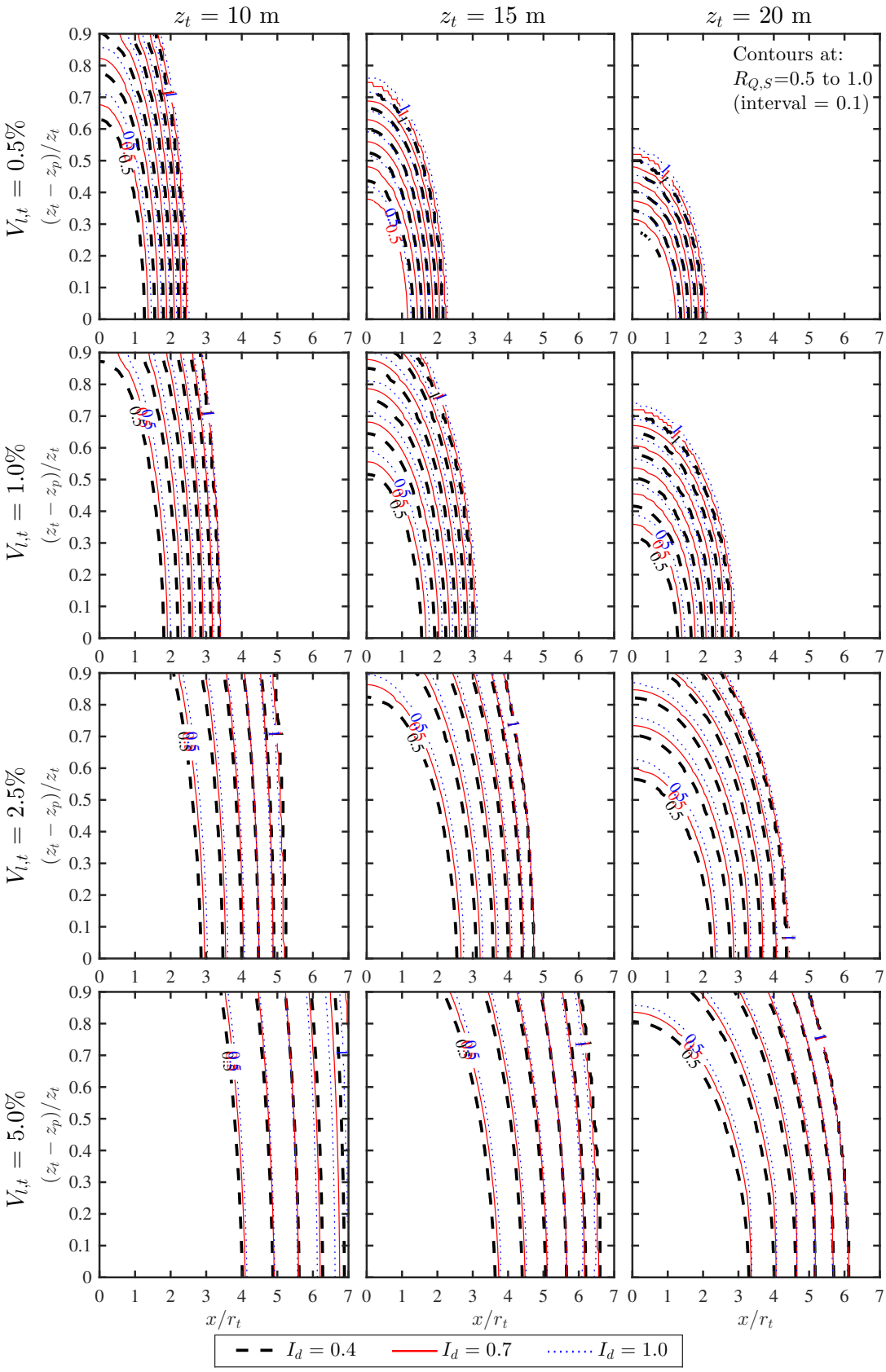

FIG. 24. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=30°

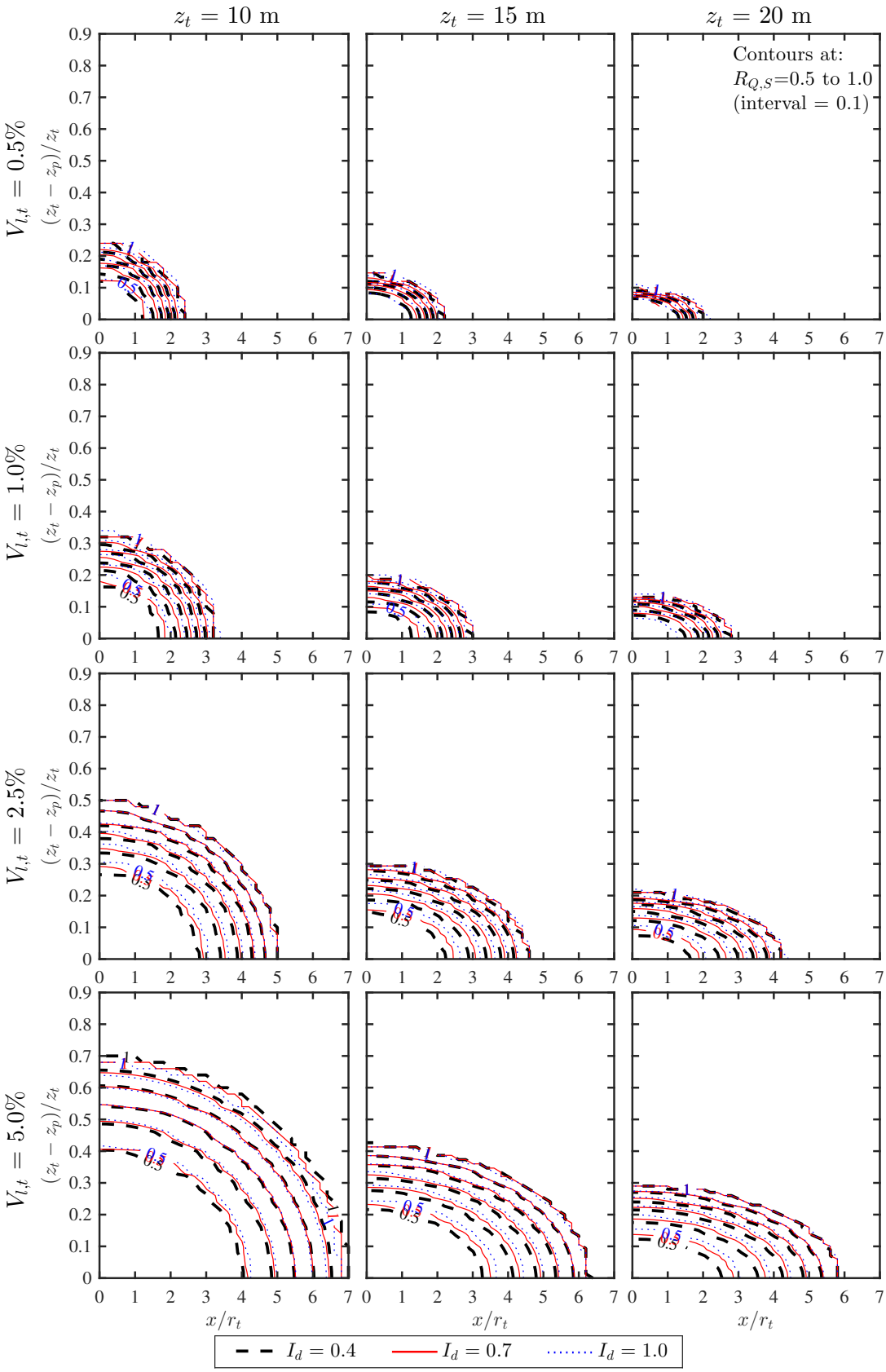

FIG. 25. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

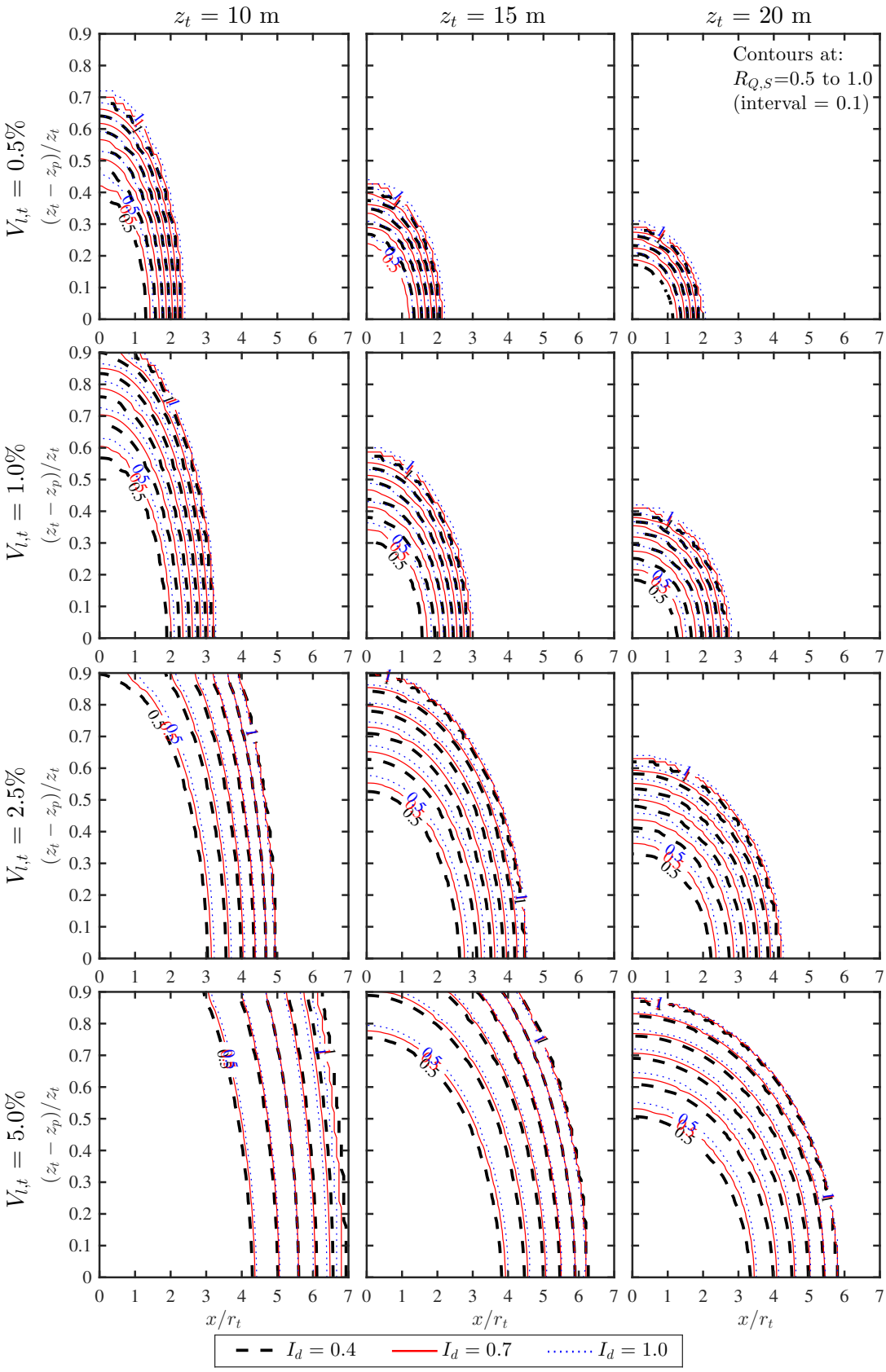

FIG. 26. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

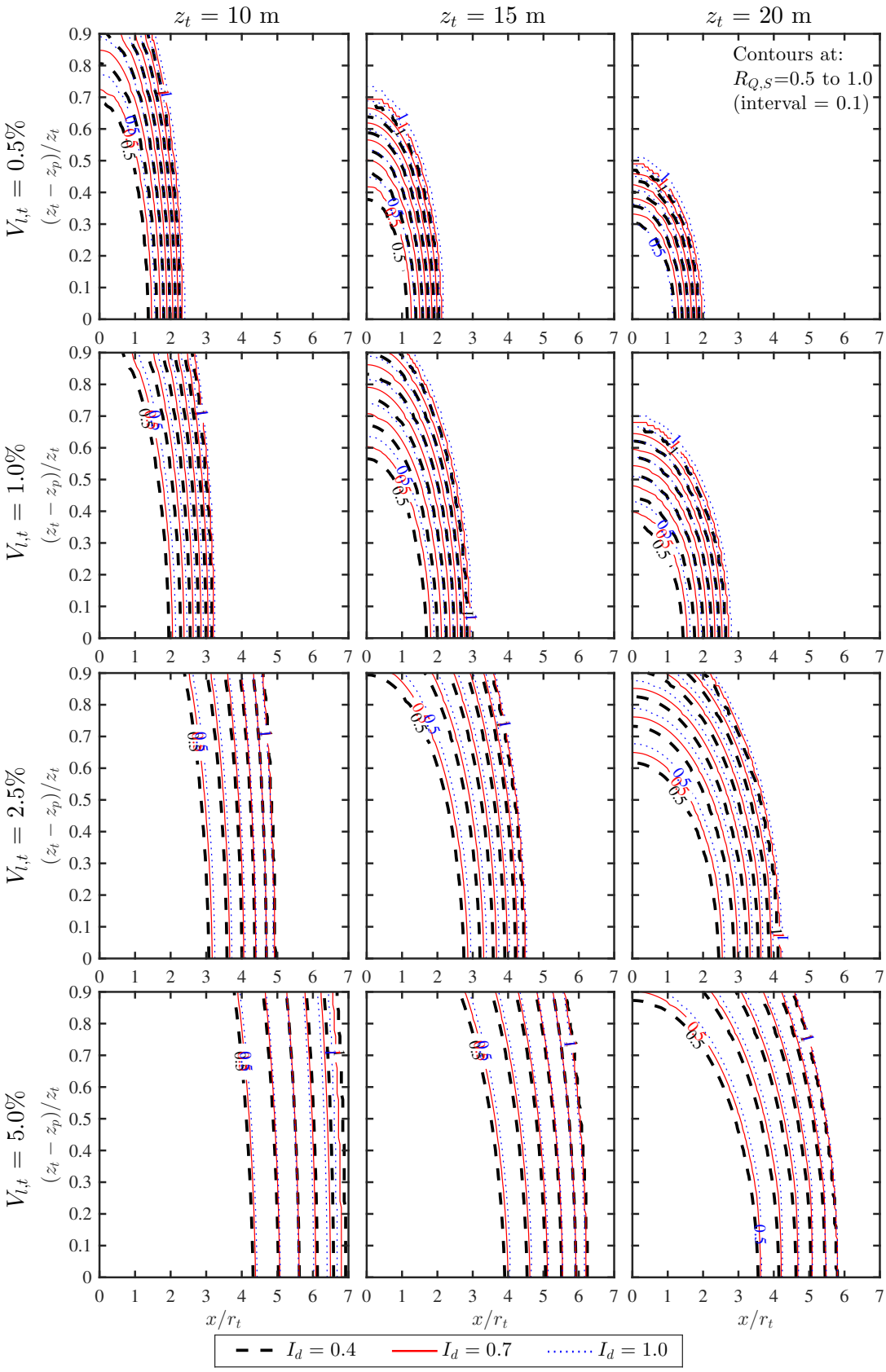

FIG. 27. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4;0.7;1.0, ϕ'_{cv}=35°

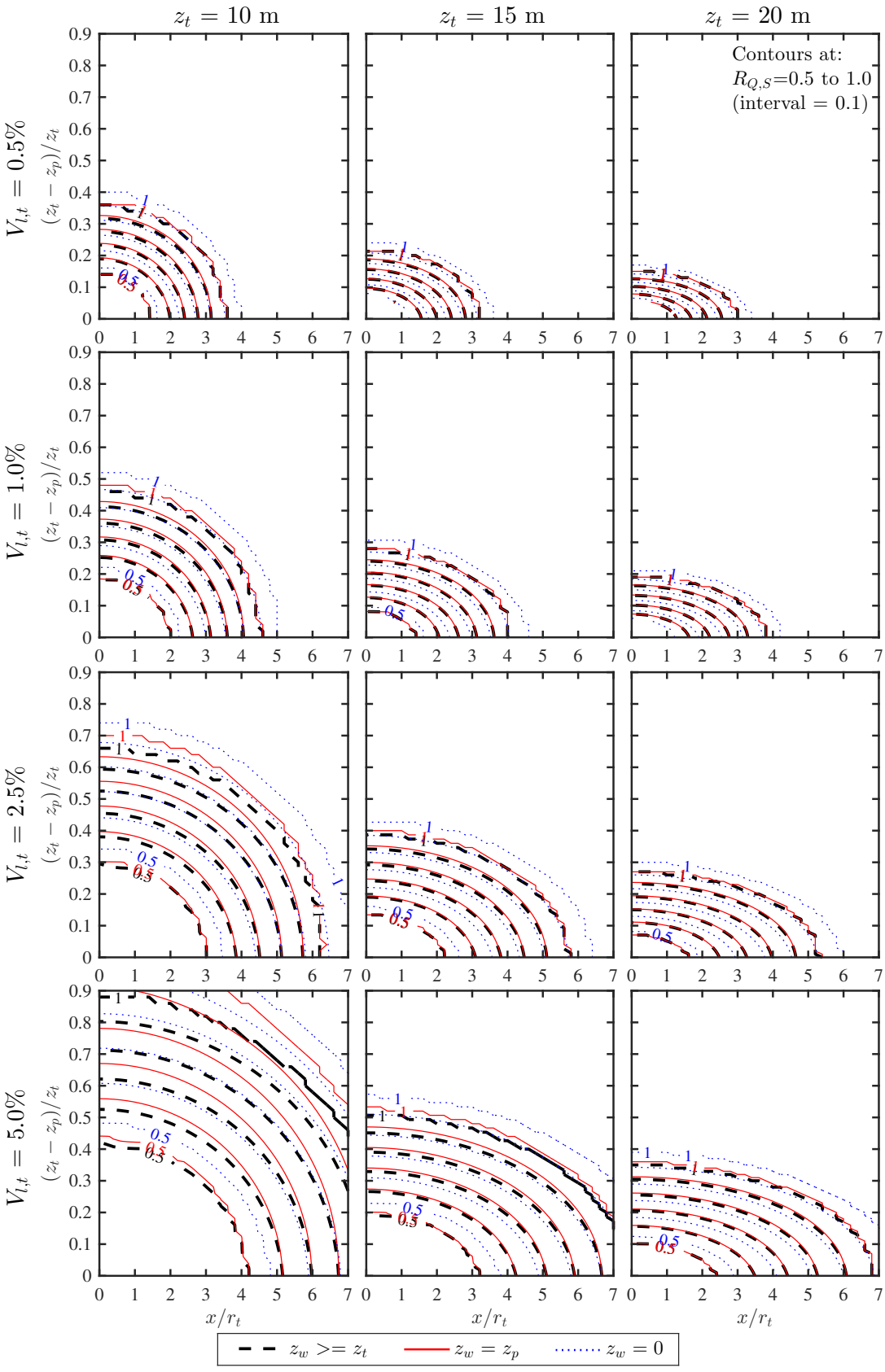

FIG. 28. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

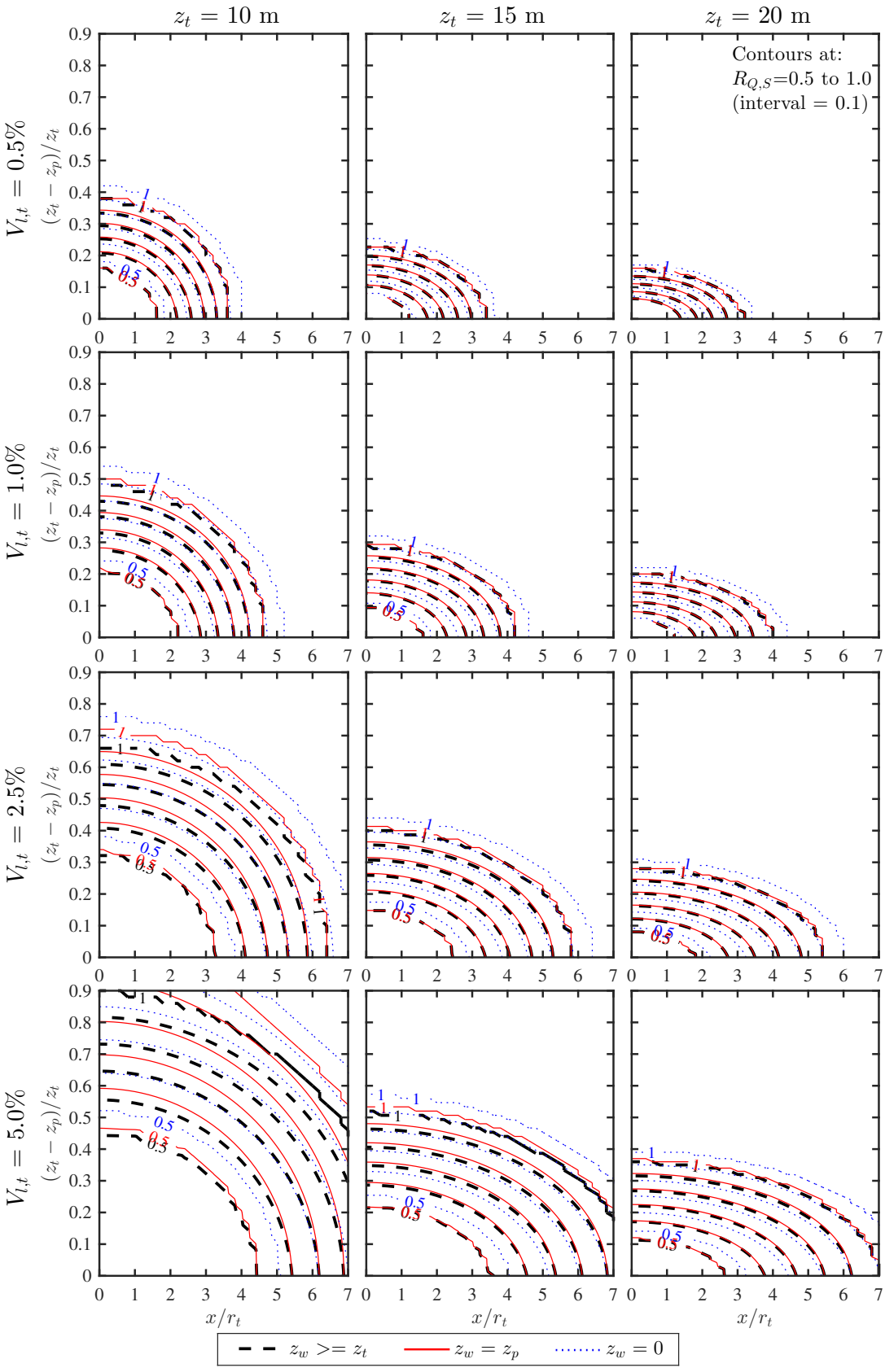

FIG. 29. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.7, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

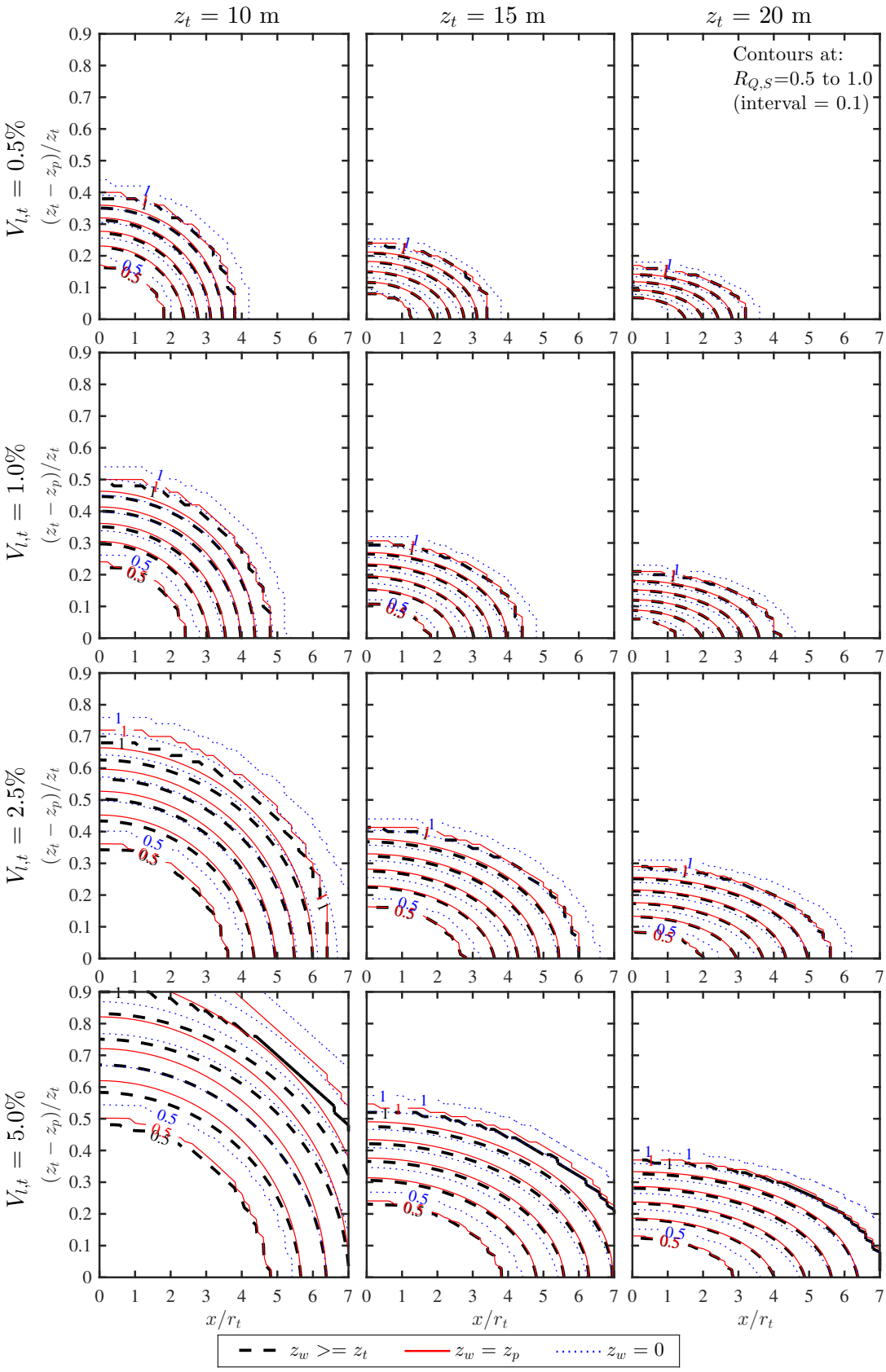

FIG. 30. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 1, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

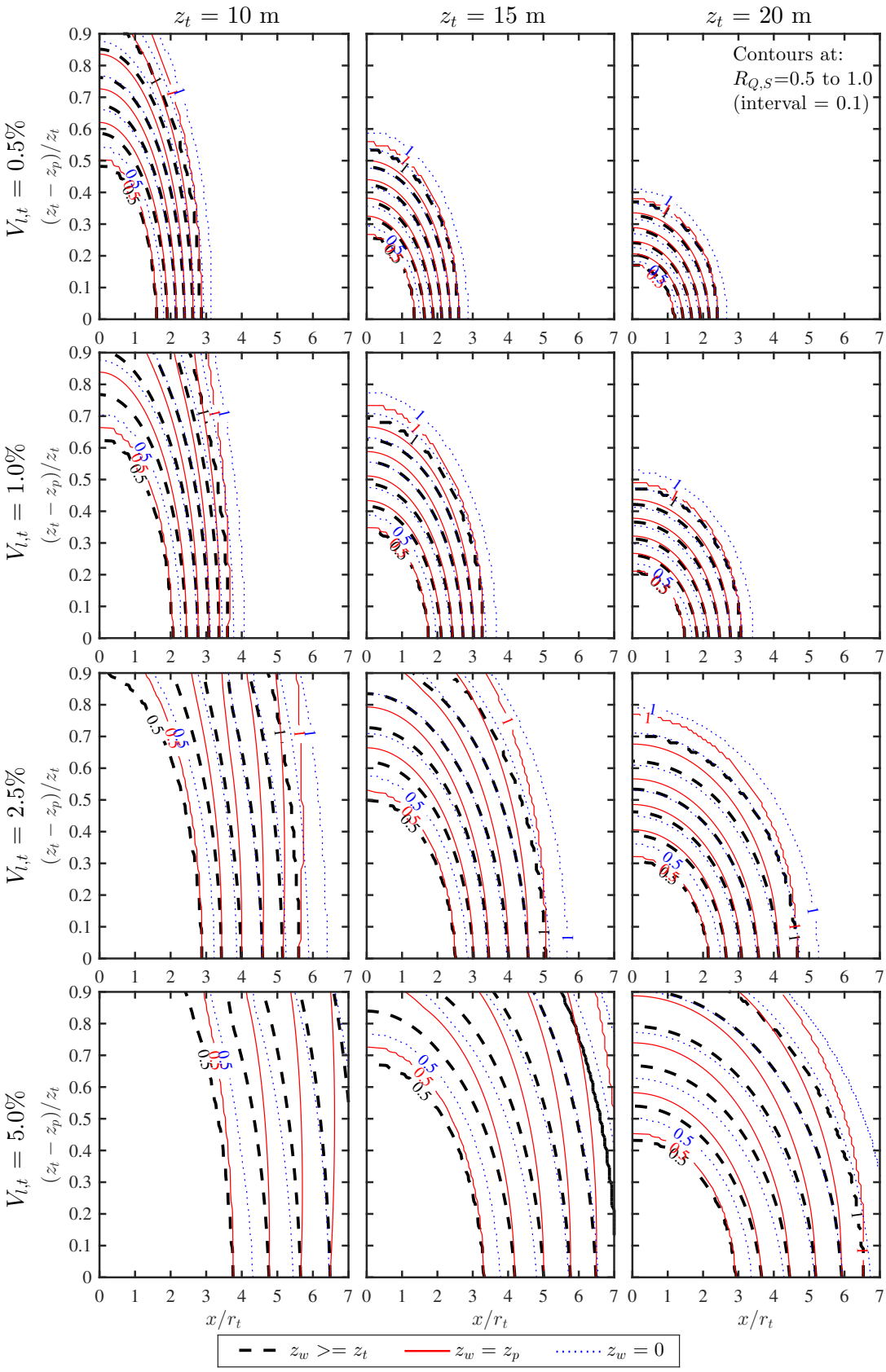

FIG. 31. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

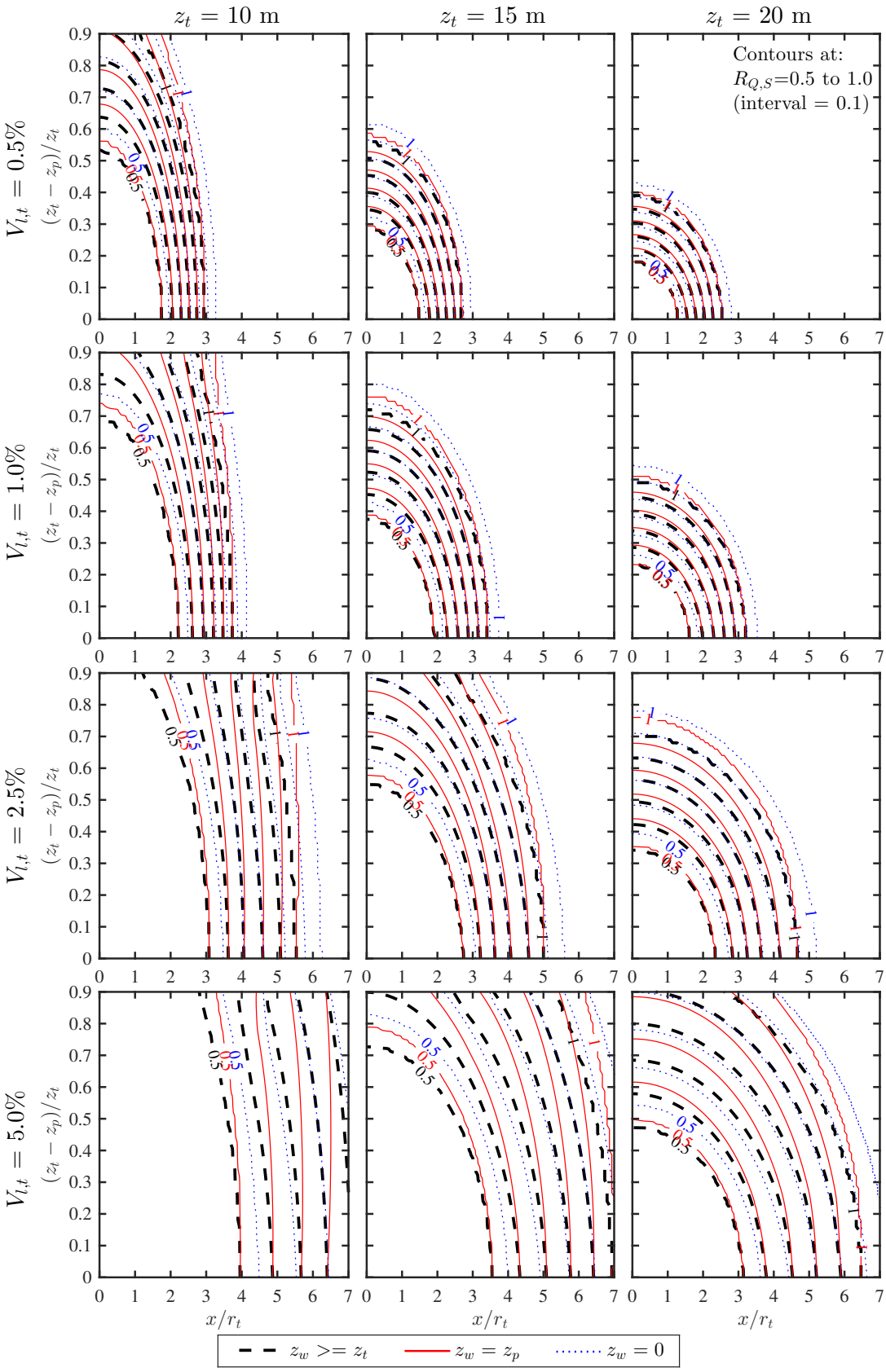

FIG. 32. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.7, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

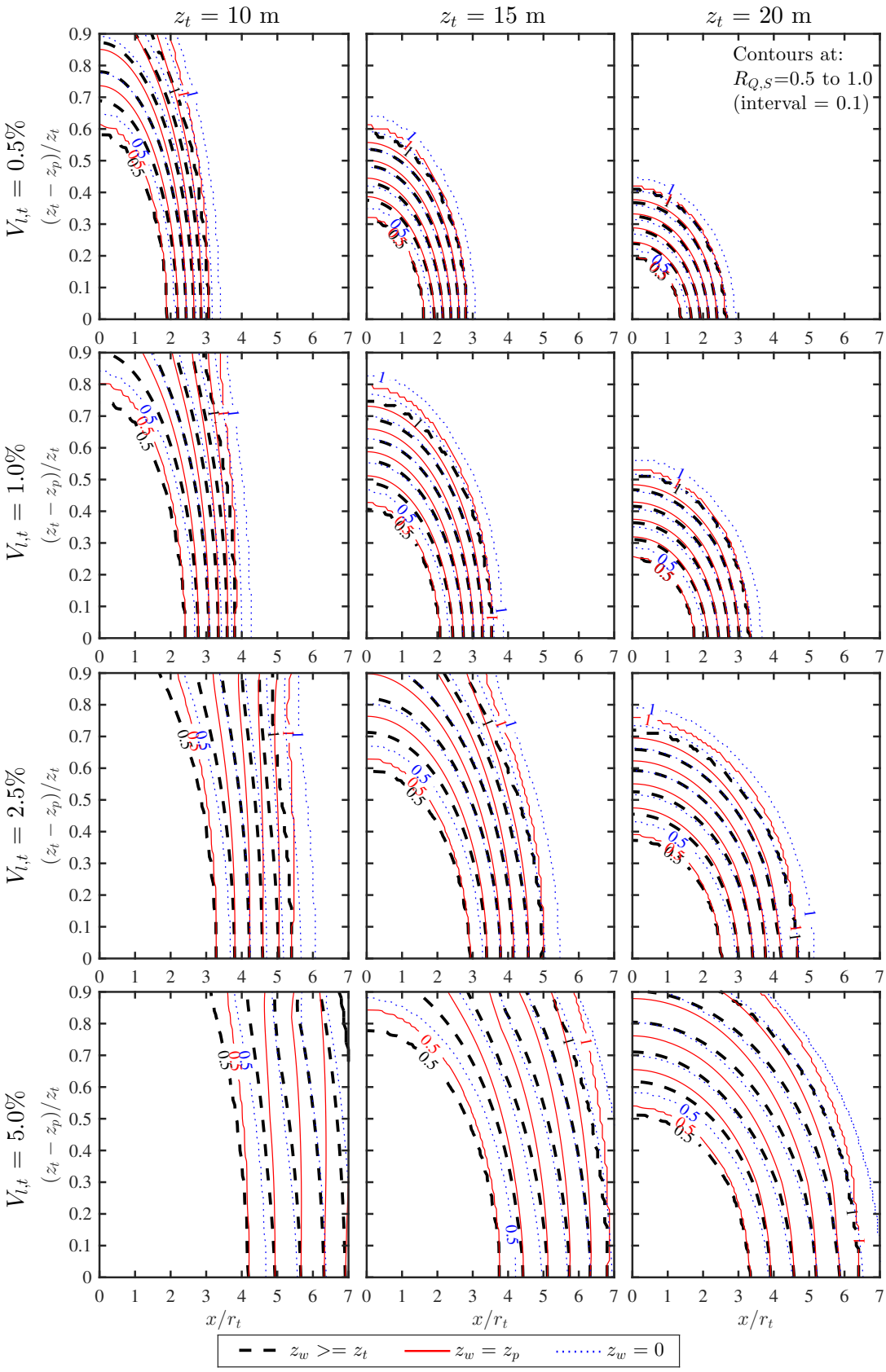

FIG. 33. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 1, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

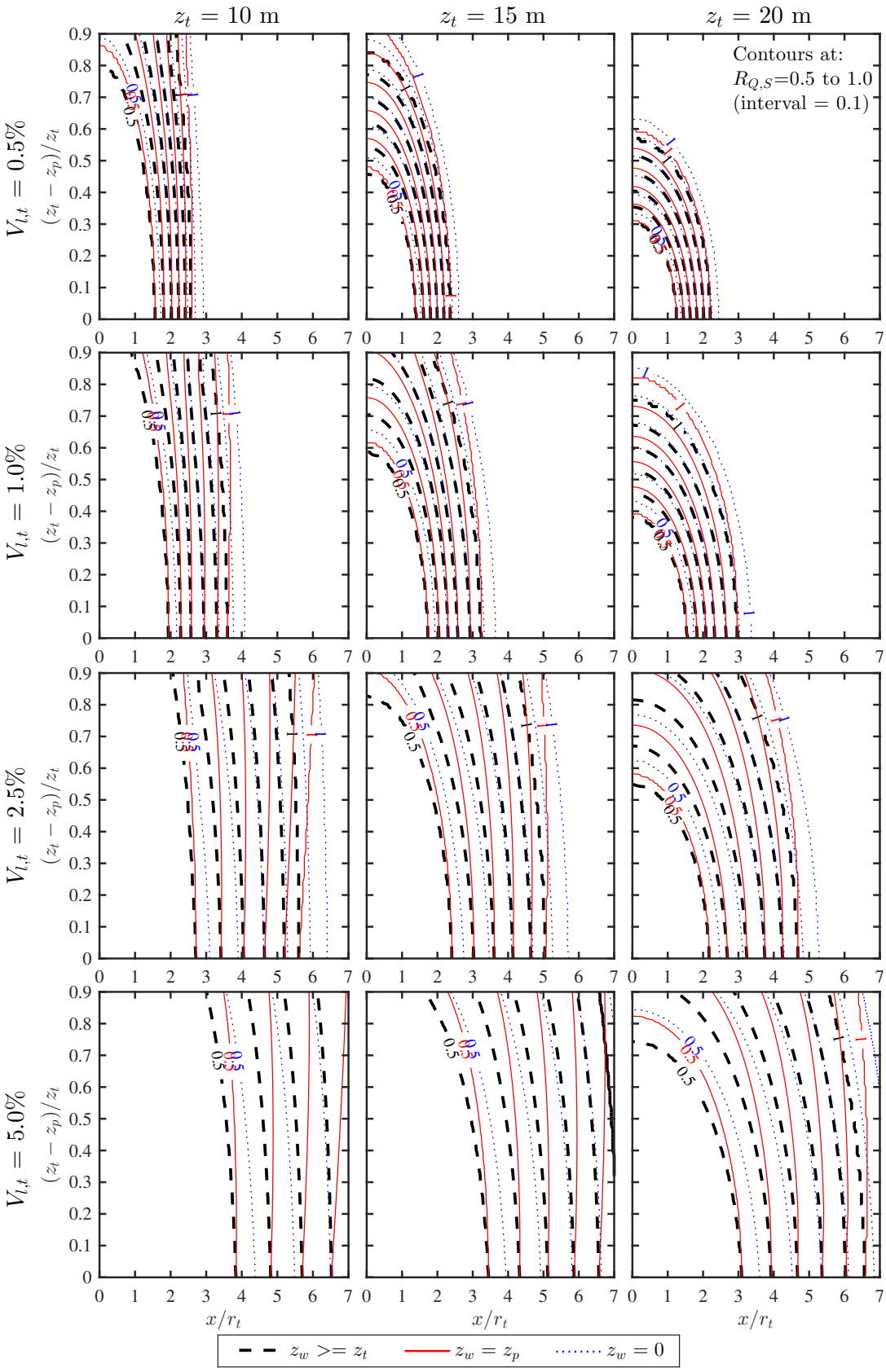

FIG. 34. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

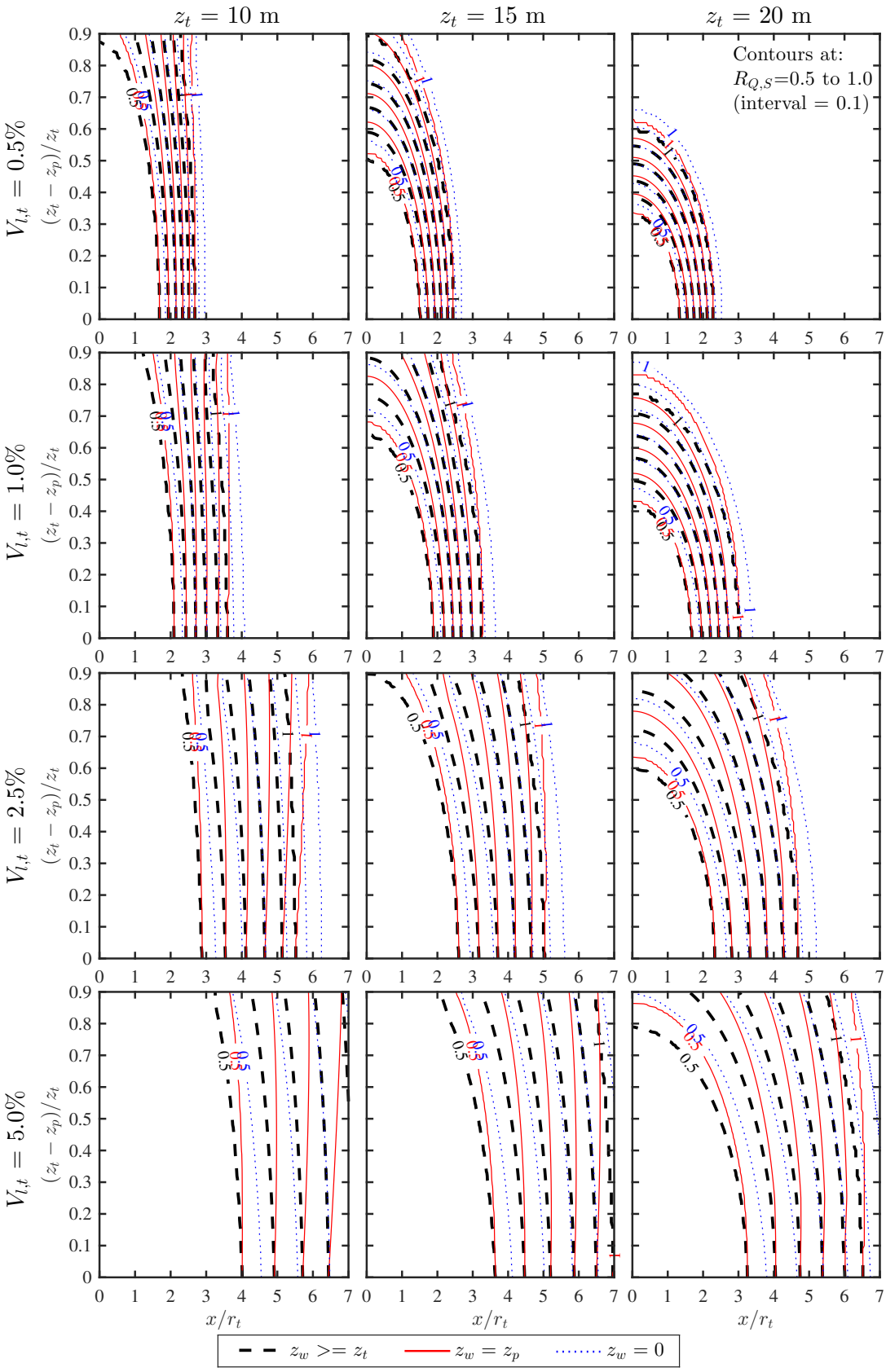

FIG. 35. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.7, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

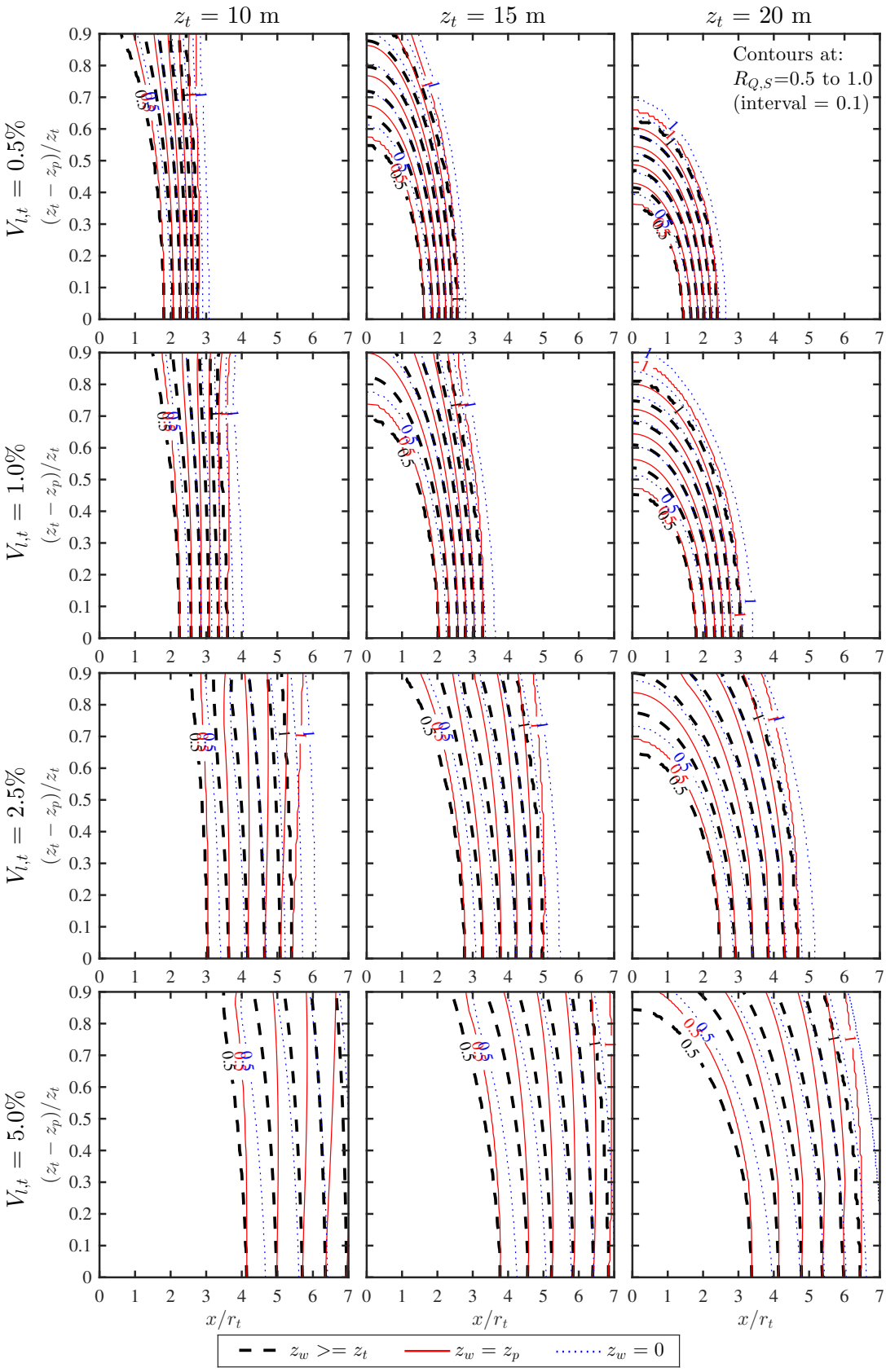

FIG. 36. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 1, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

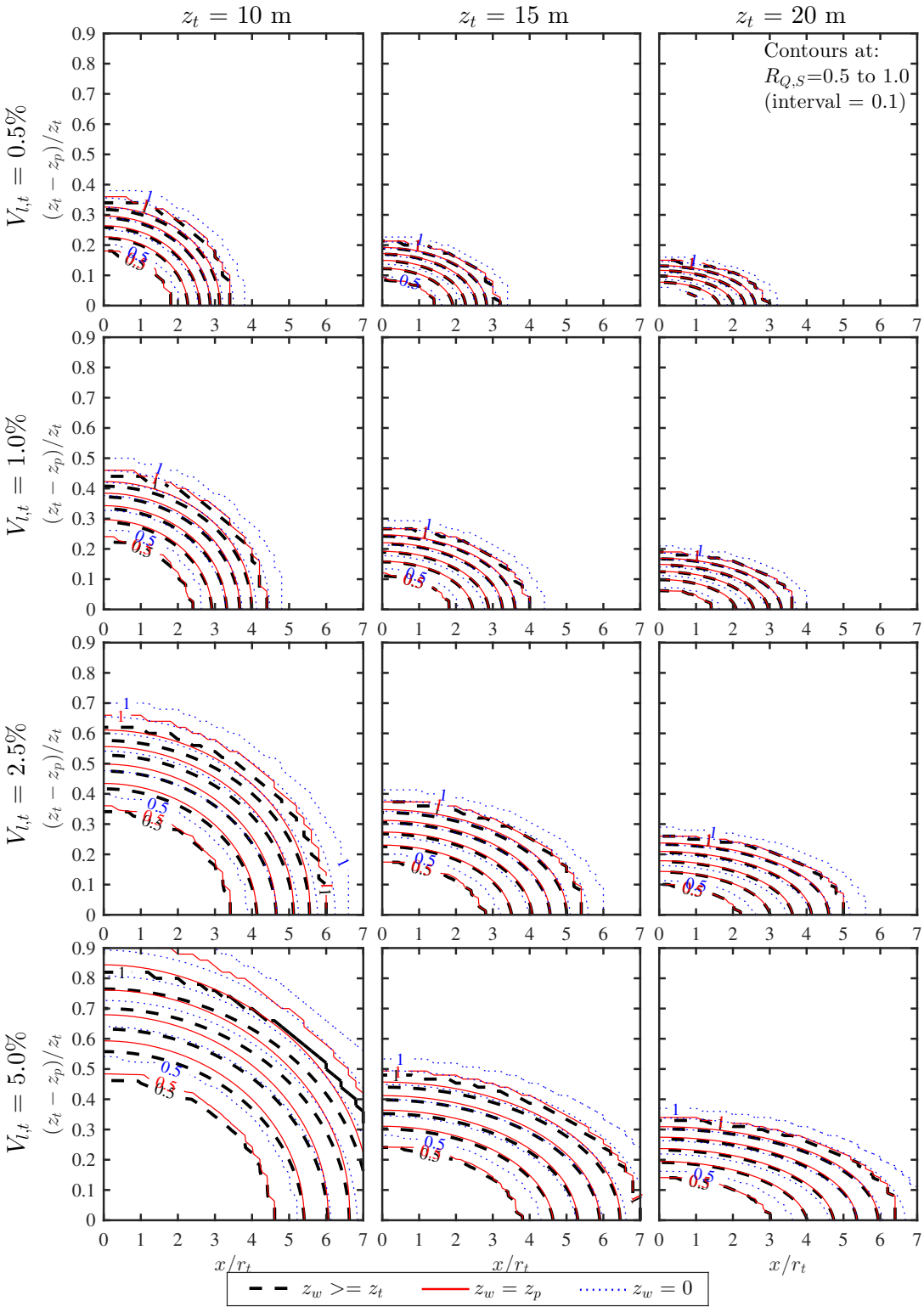

FIG. 37. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

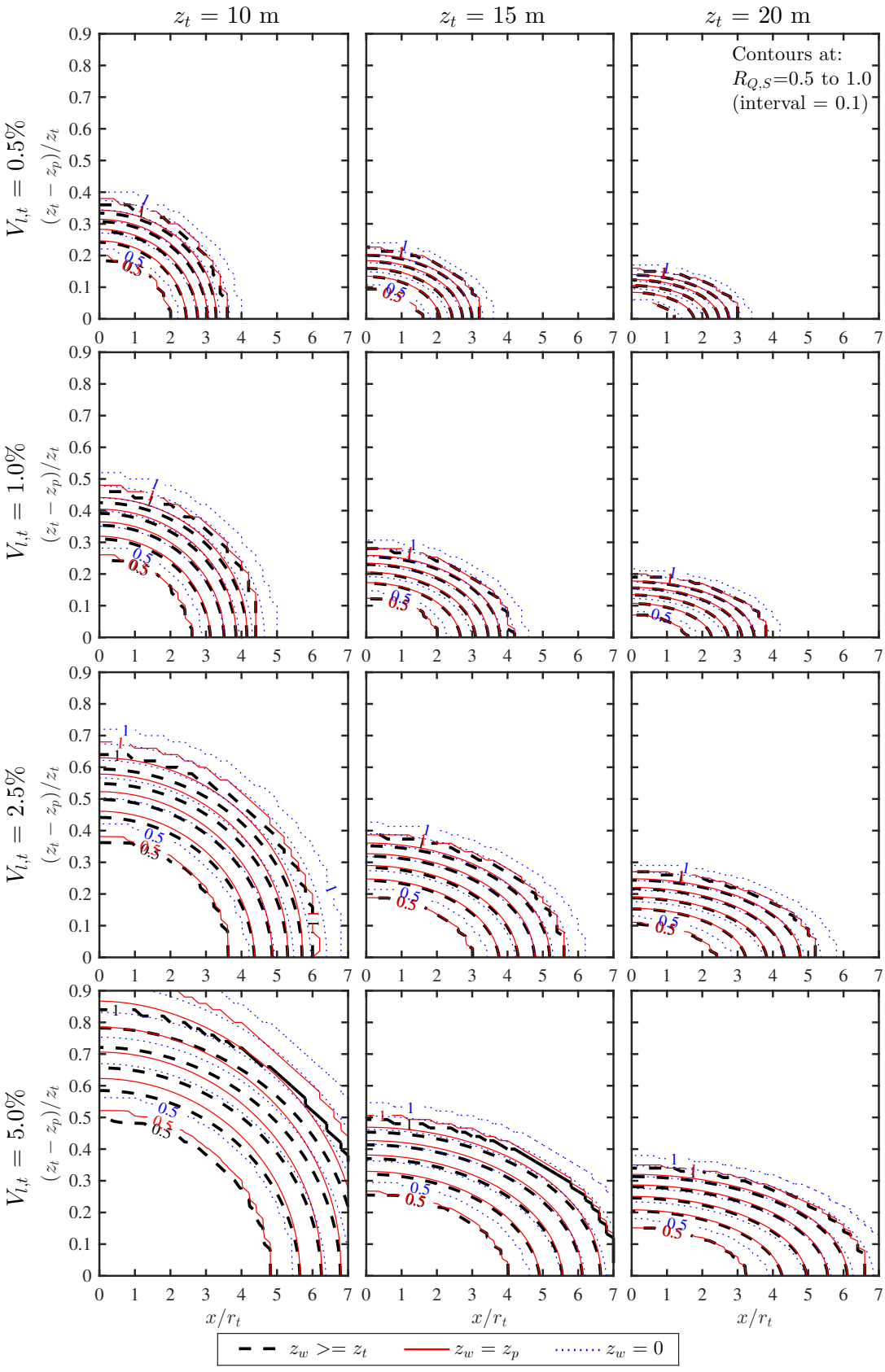

FIG. 38. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.7, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

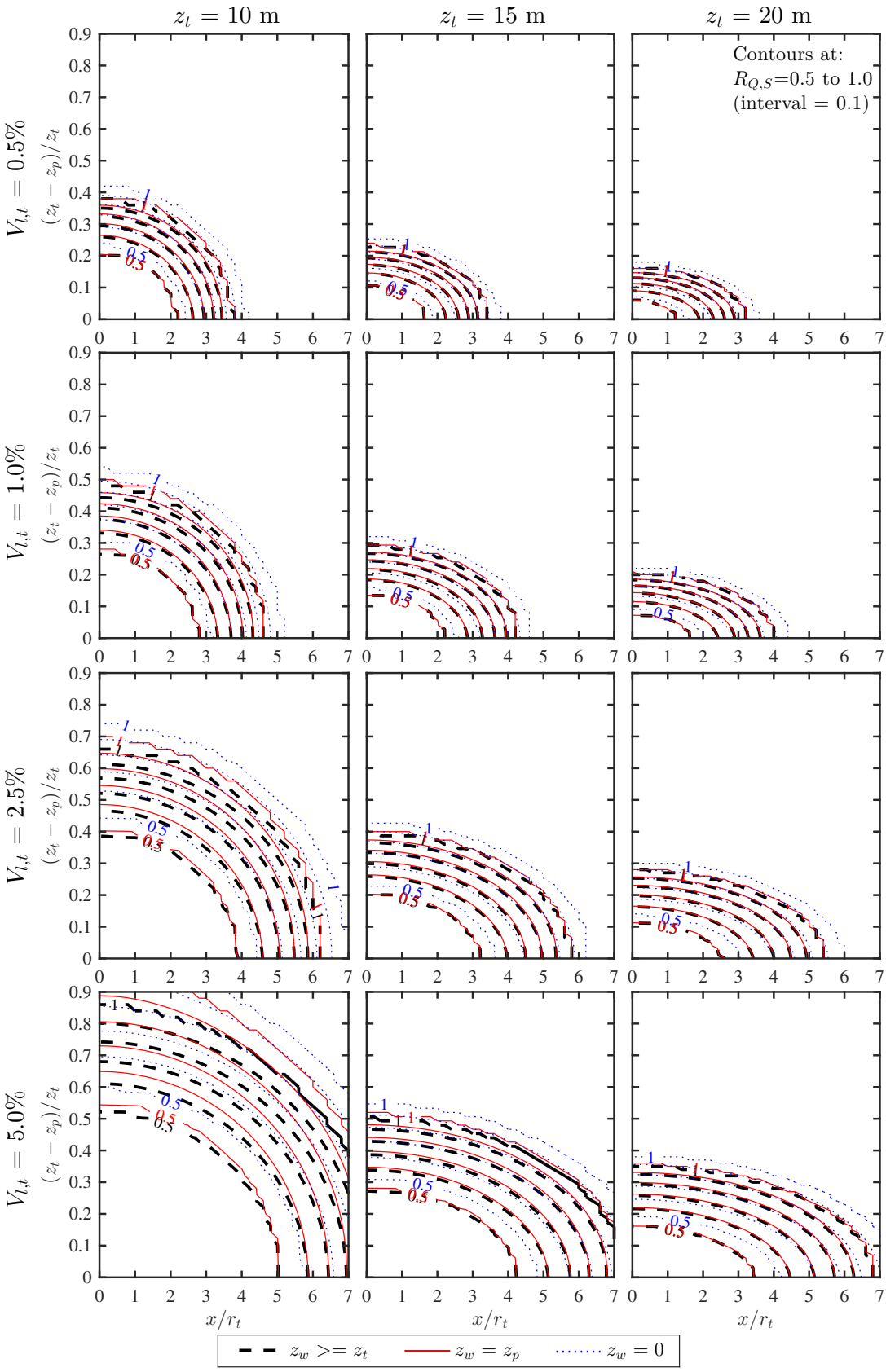

FIG. 39. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 1, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

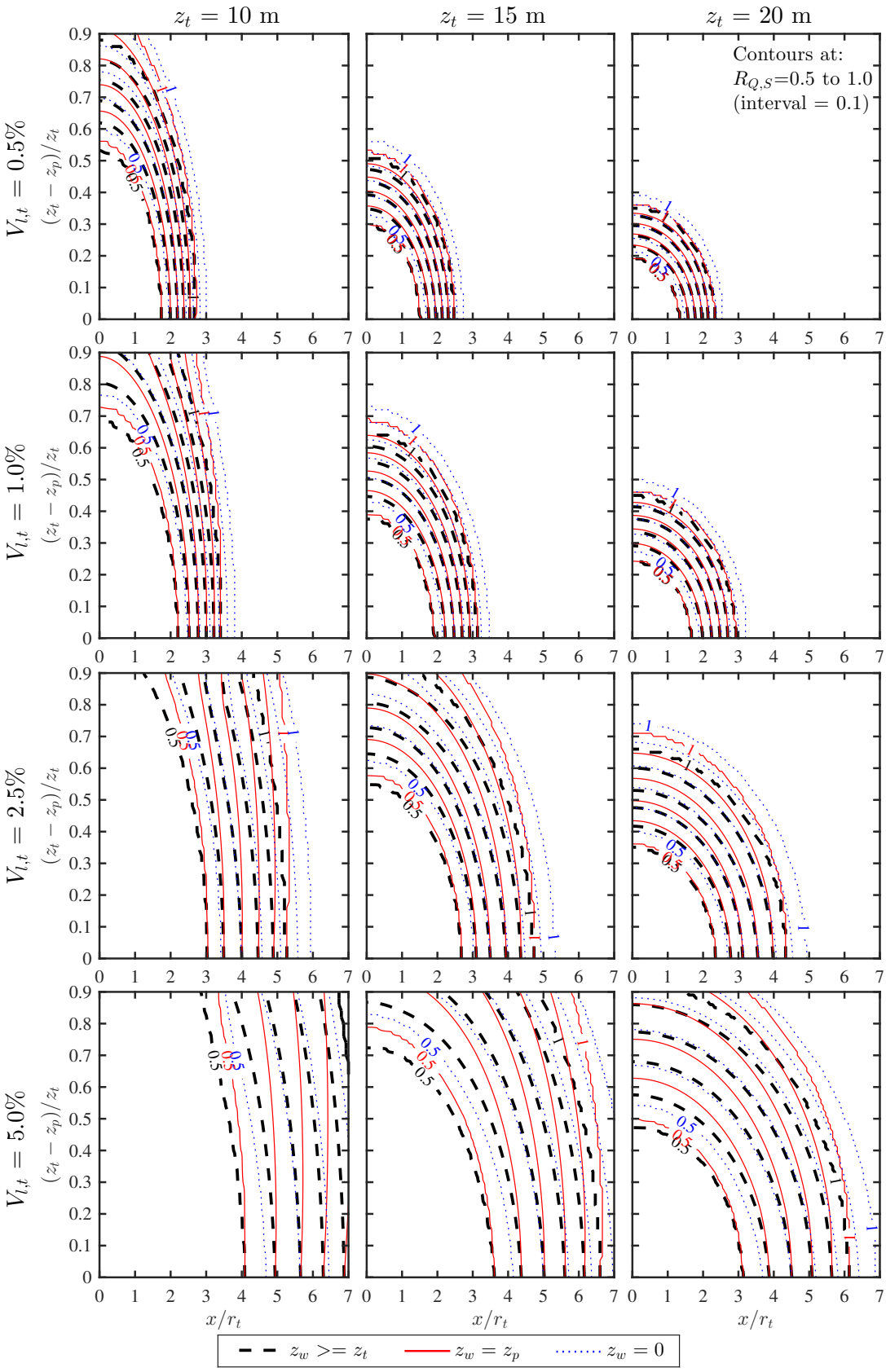

FIG. 40. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

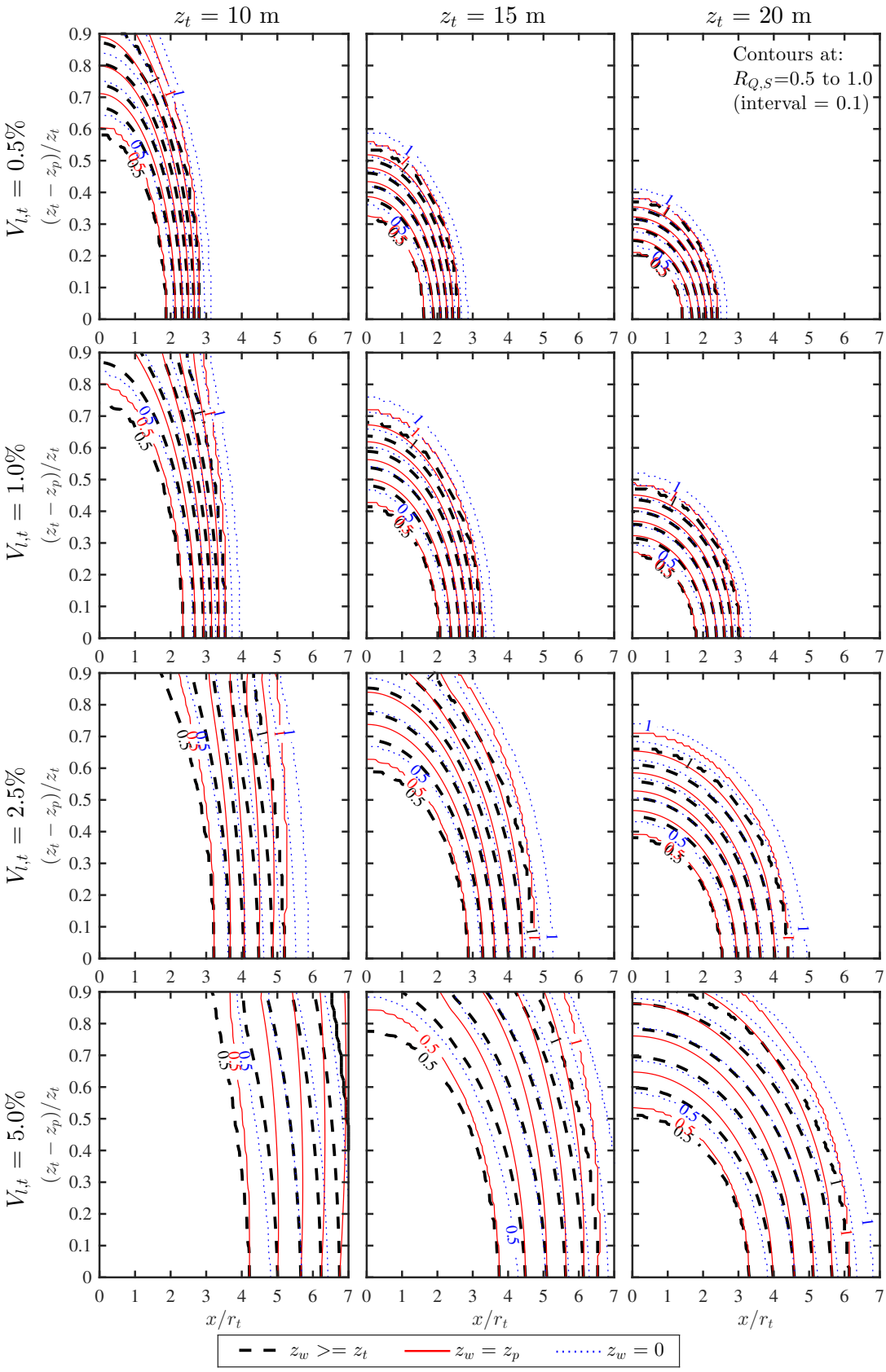

FIG. 41. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.7, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

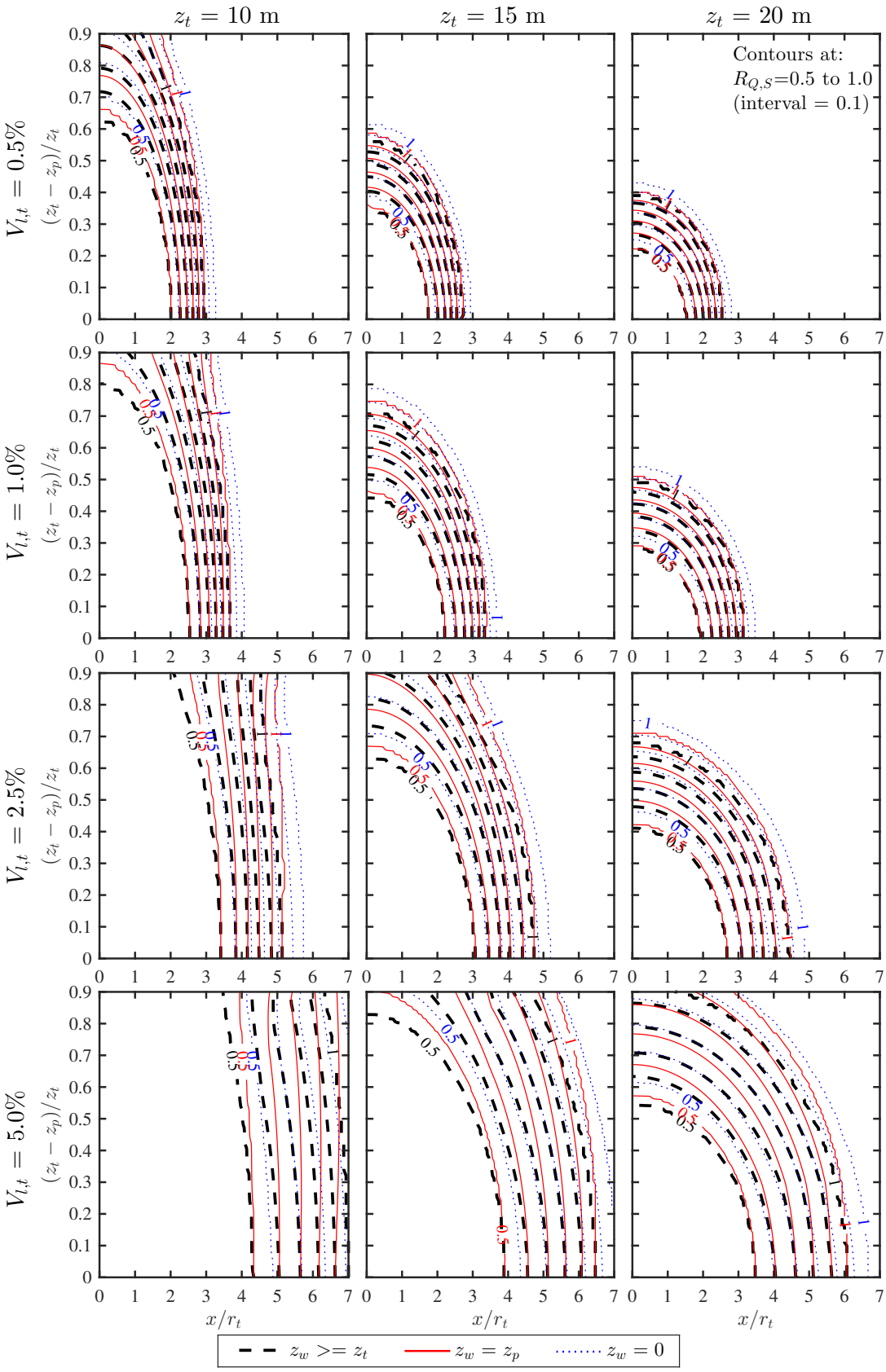

FIG. 42. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 1, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

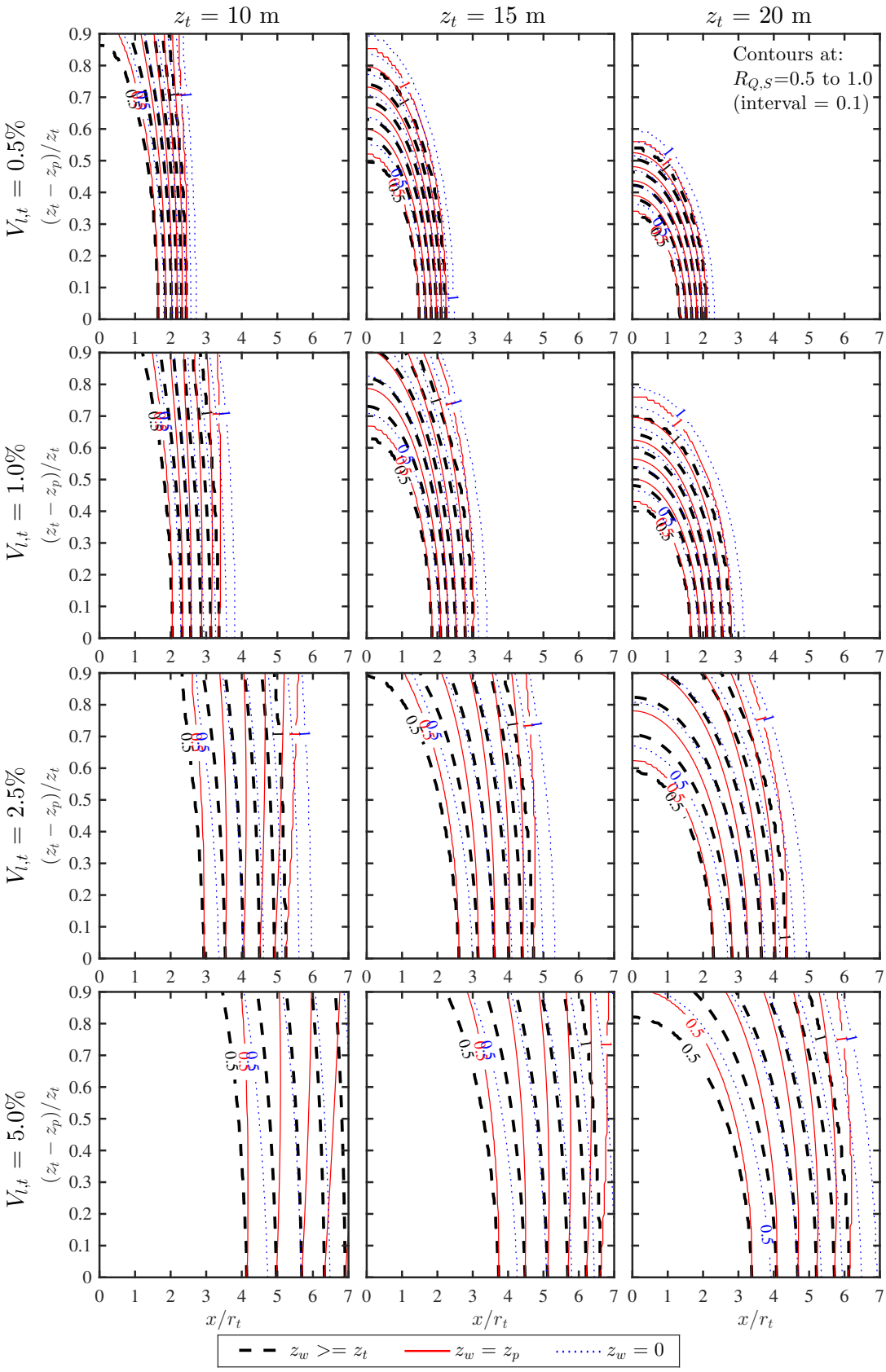

FIG. 43. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

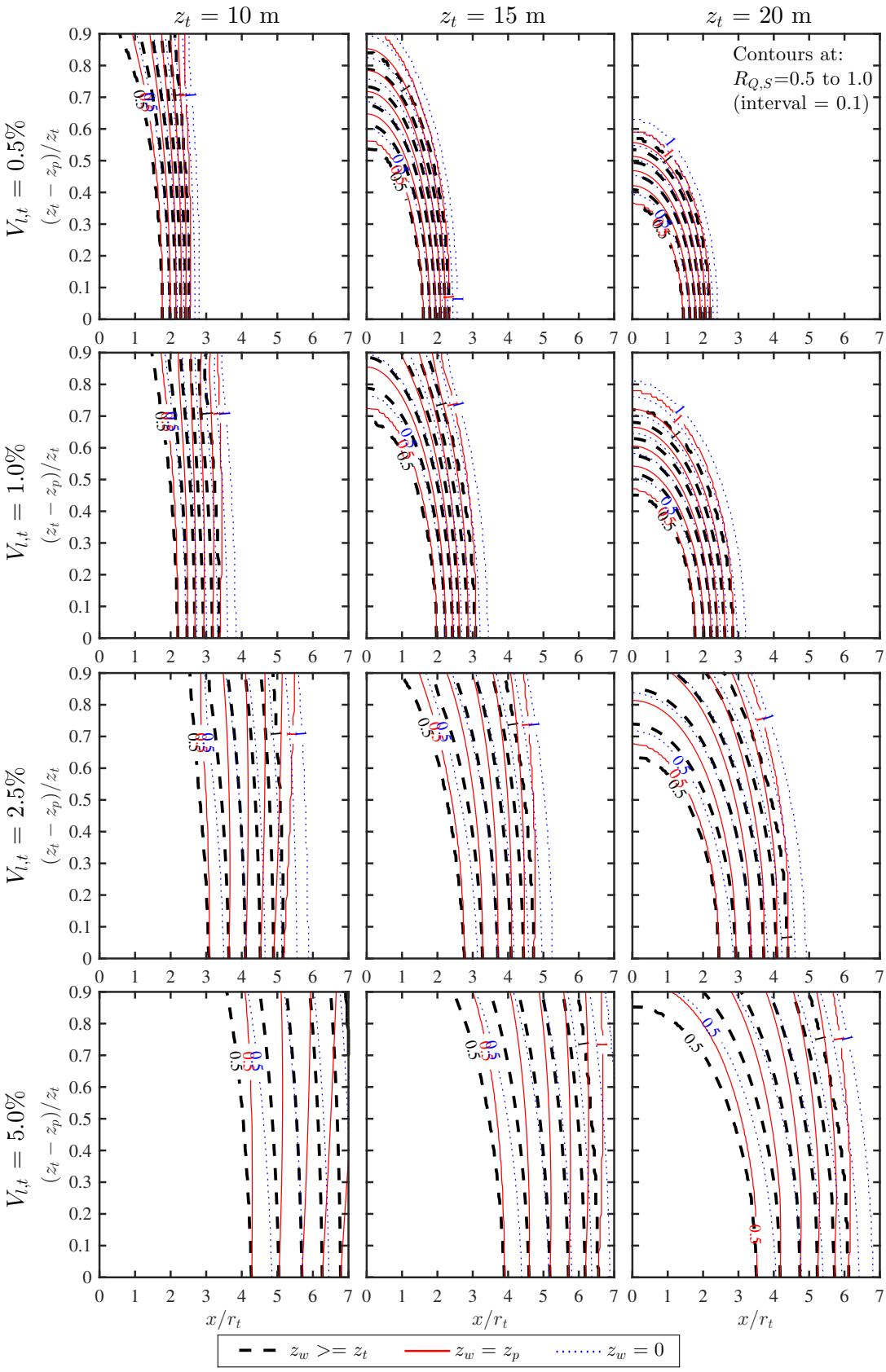

FIG. 44. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.7, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

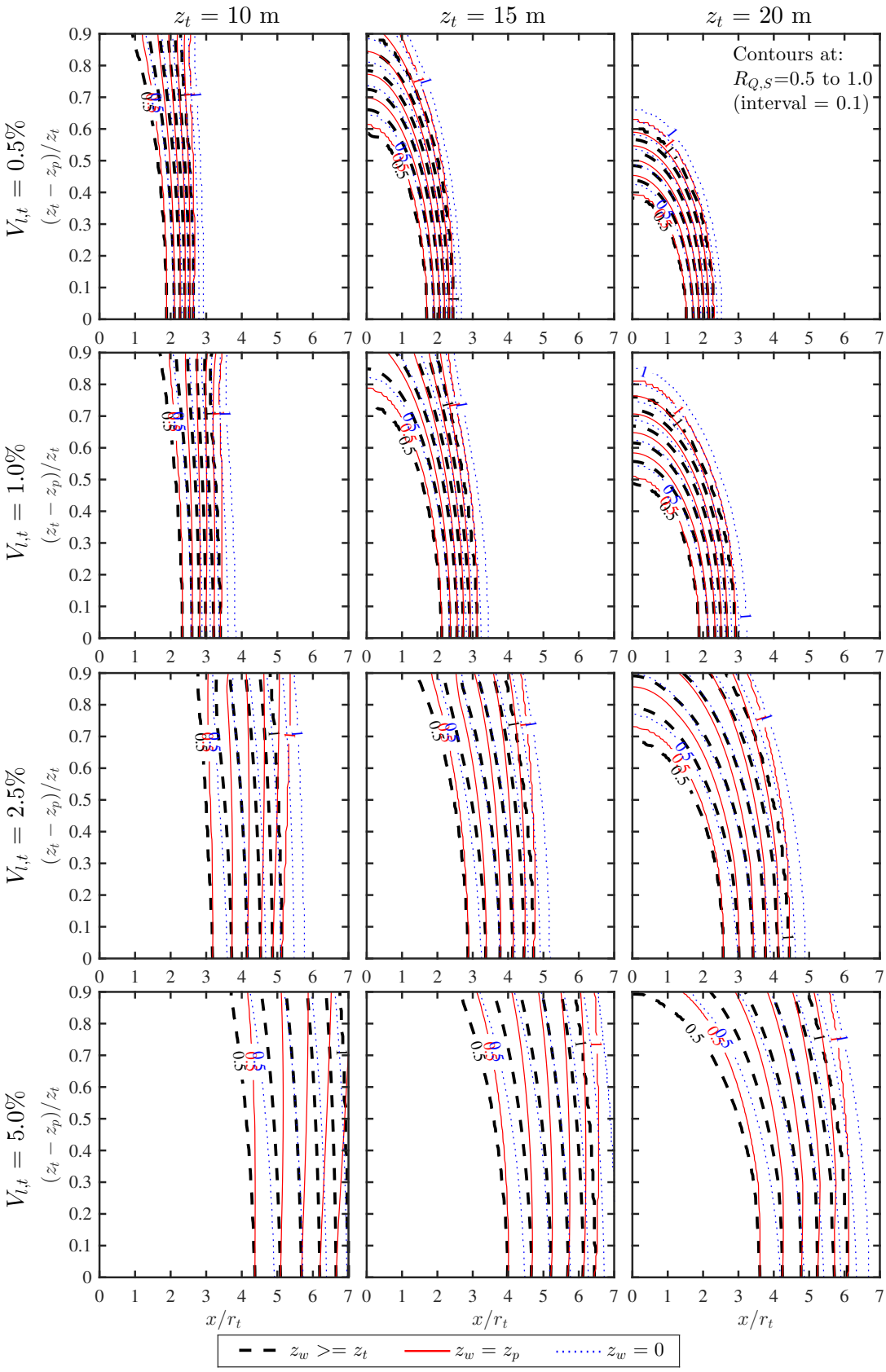

FIG. 45. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 1, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

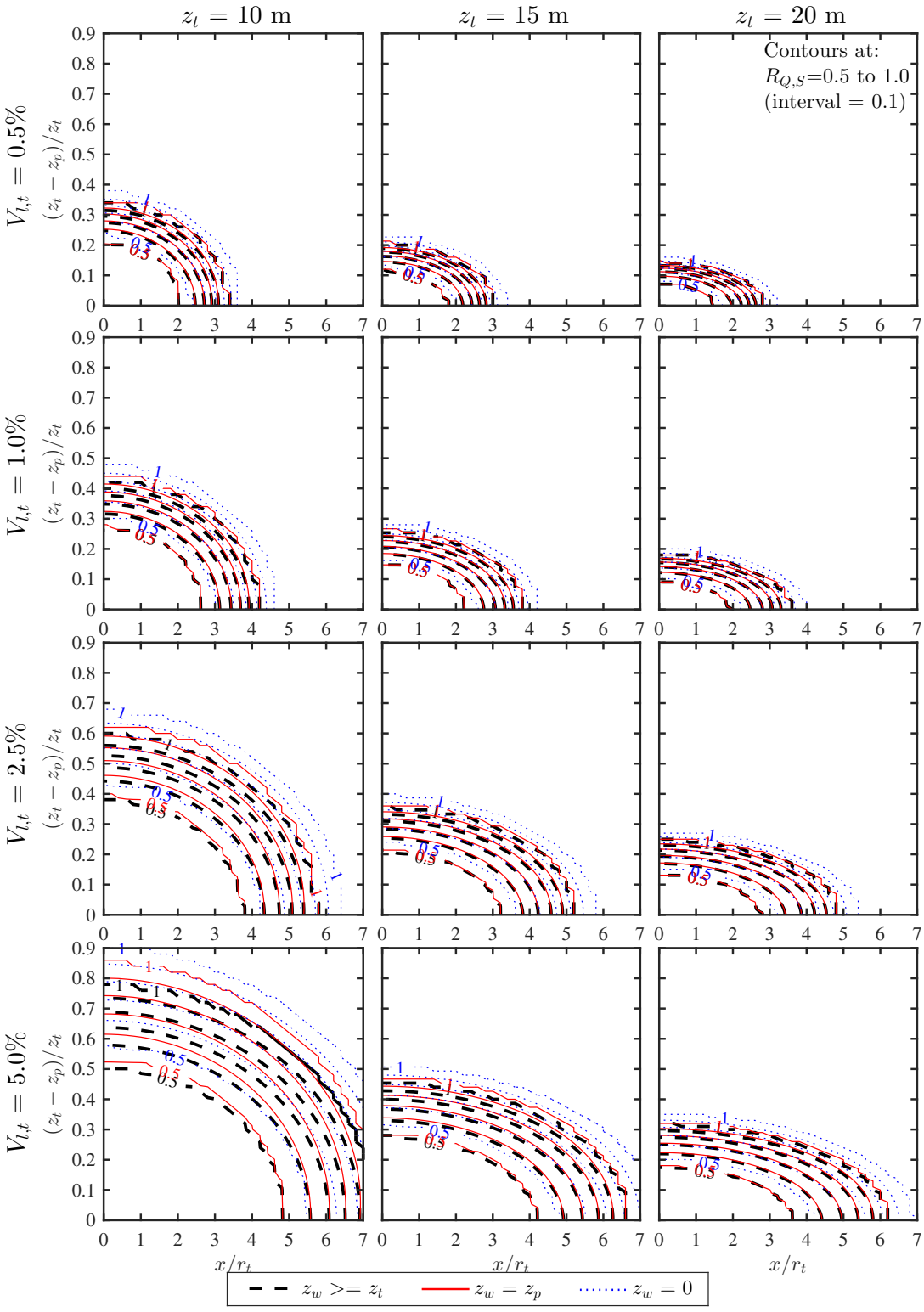

FIG. 46. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

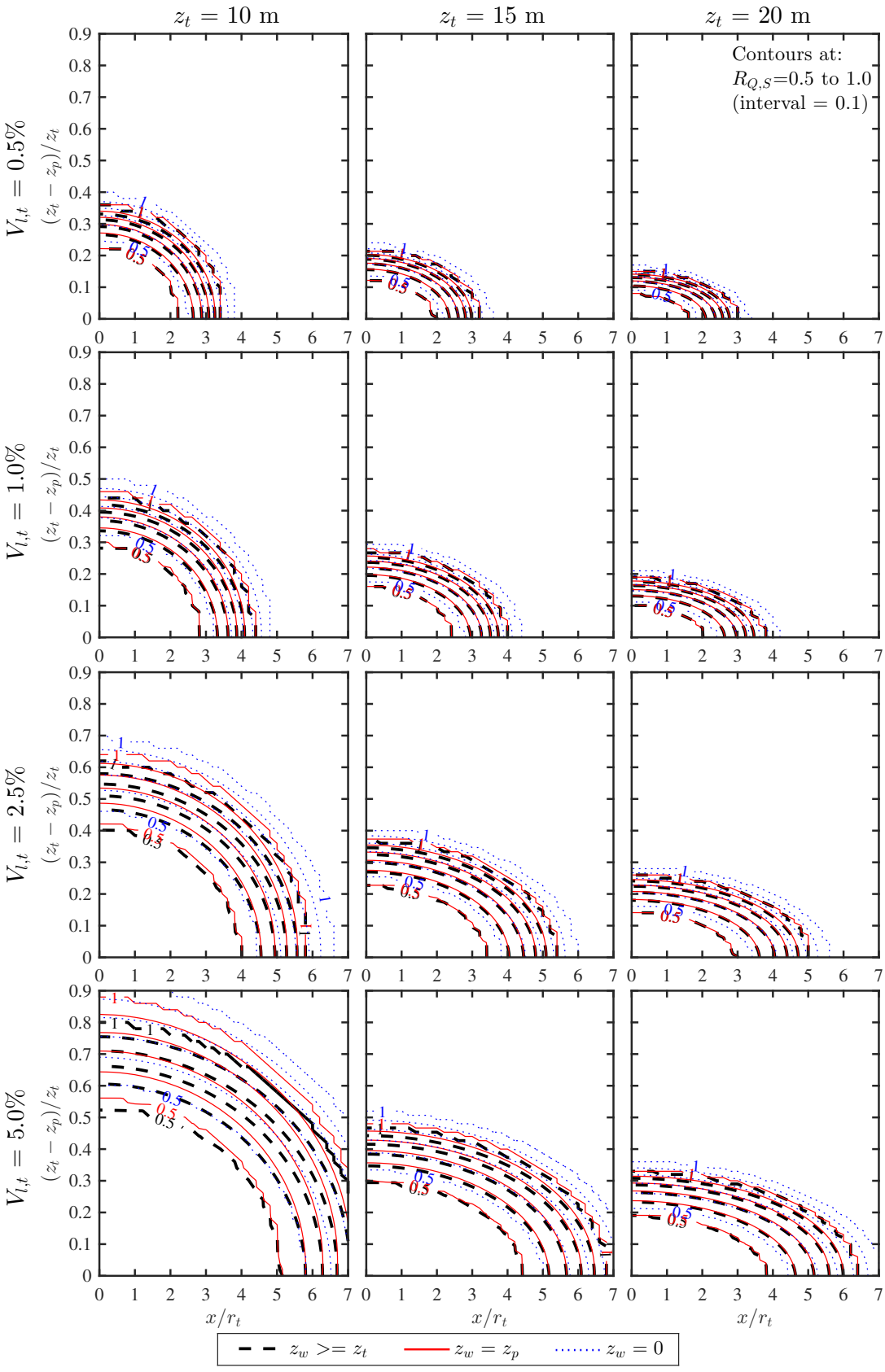

FIG. 47. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.7, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

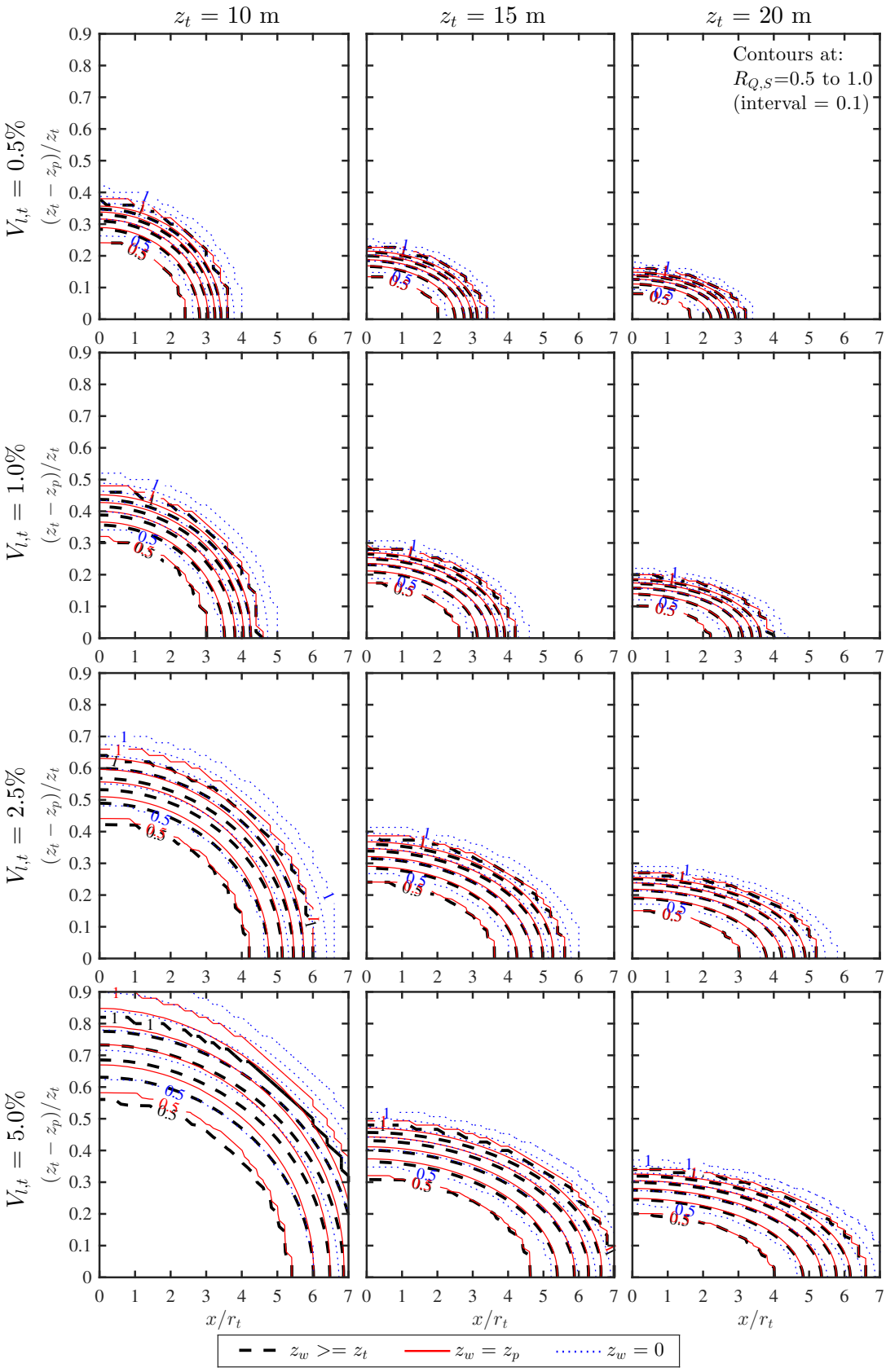

FIG. 48. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 1, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

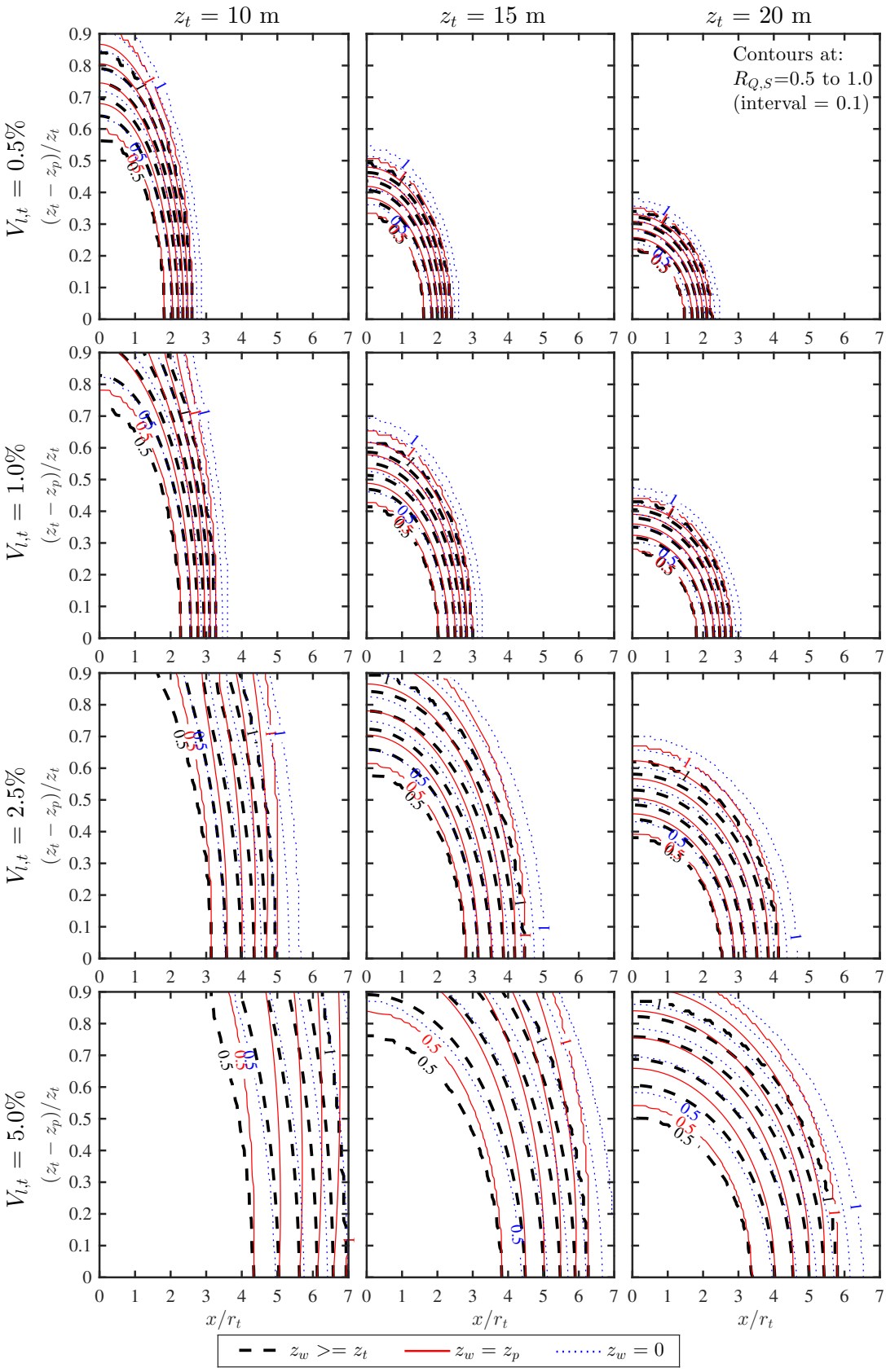

FIG. 49. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

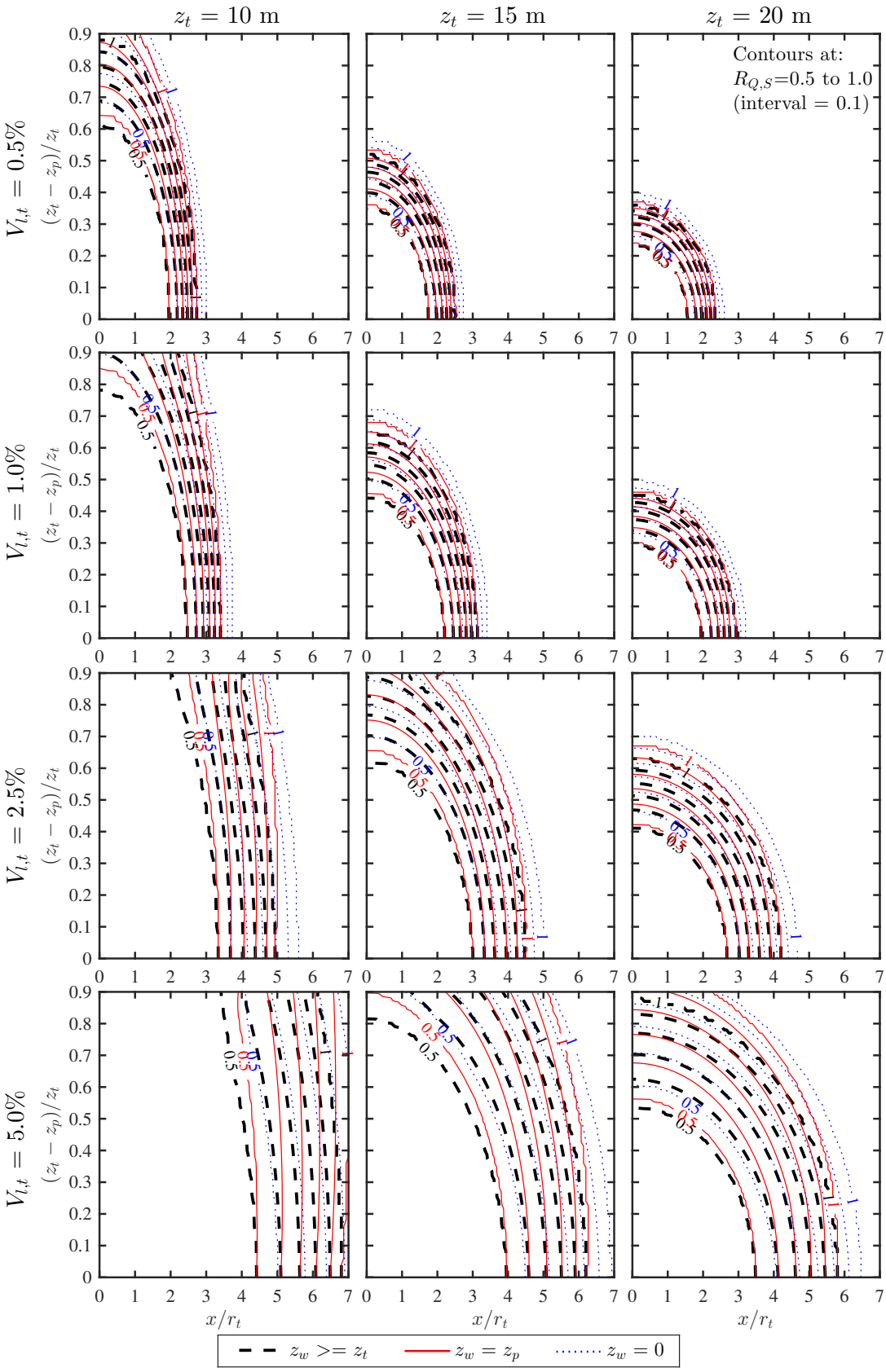

FIG. 50. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.7, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

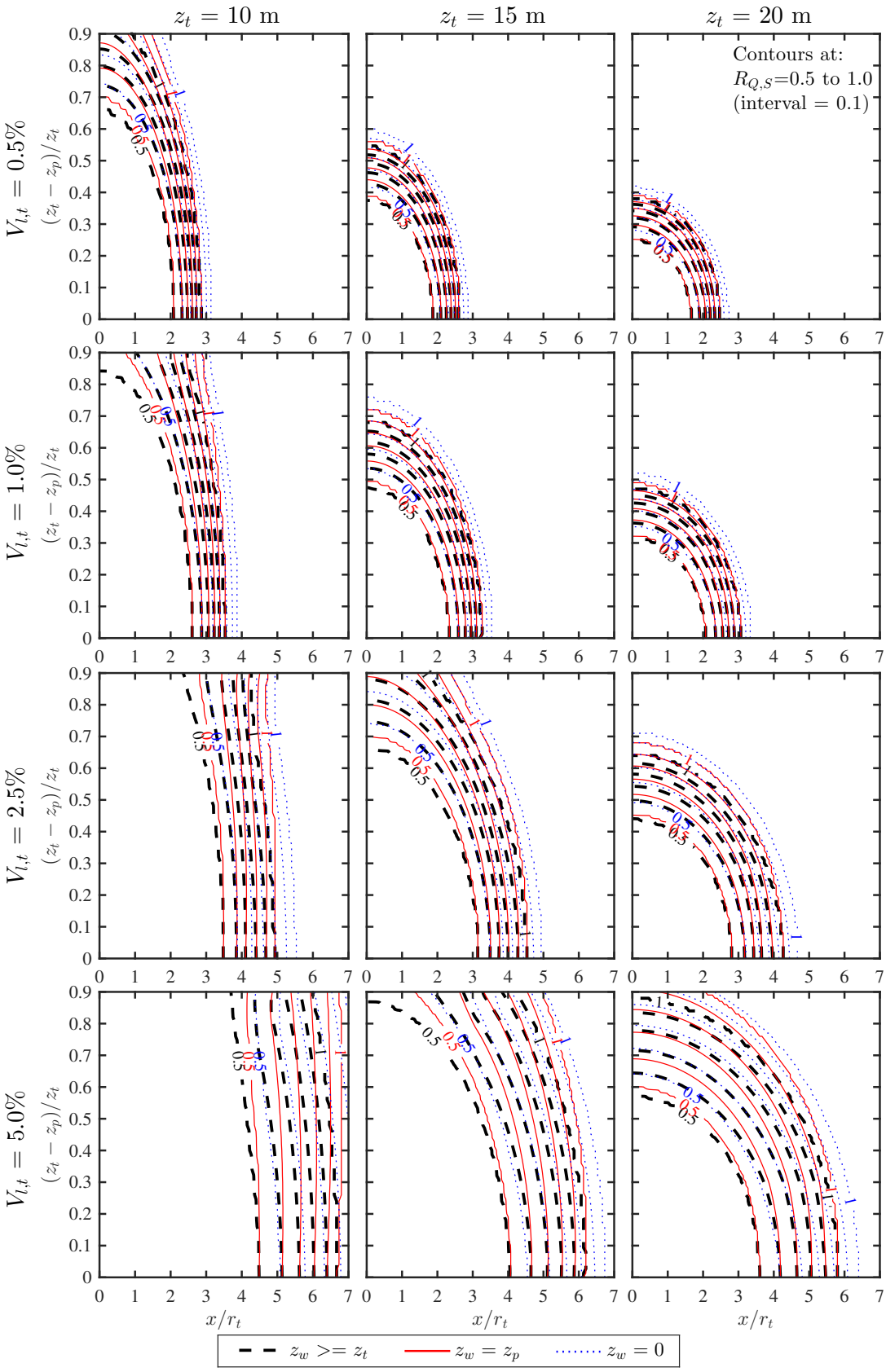

FIG. 51. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 1, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

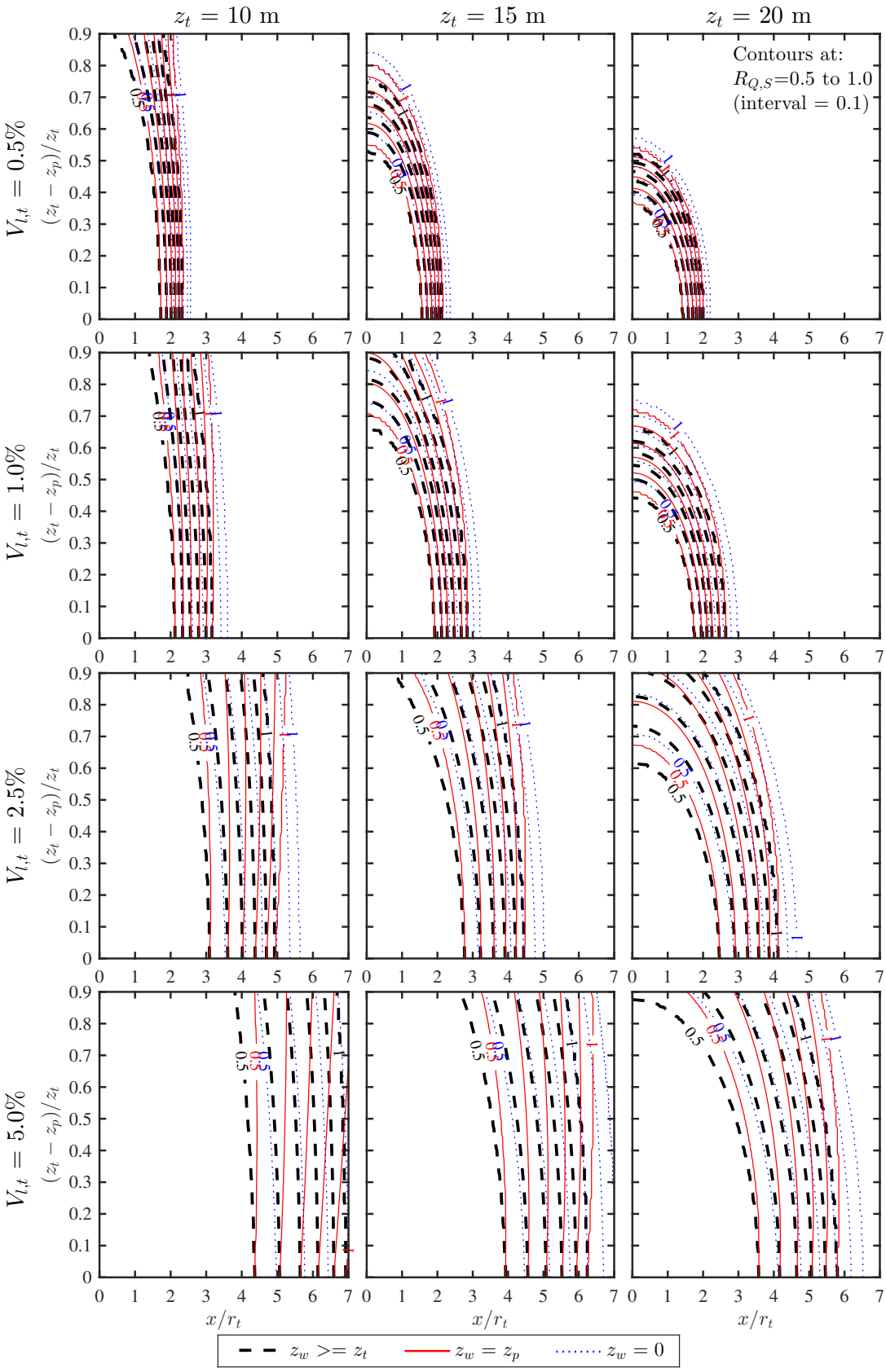

FIG. 52. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

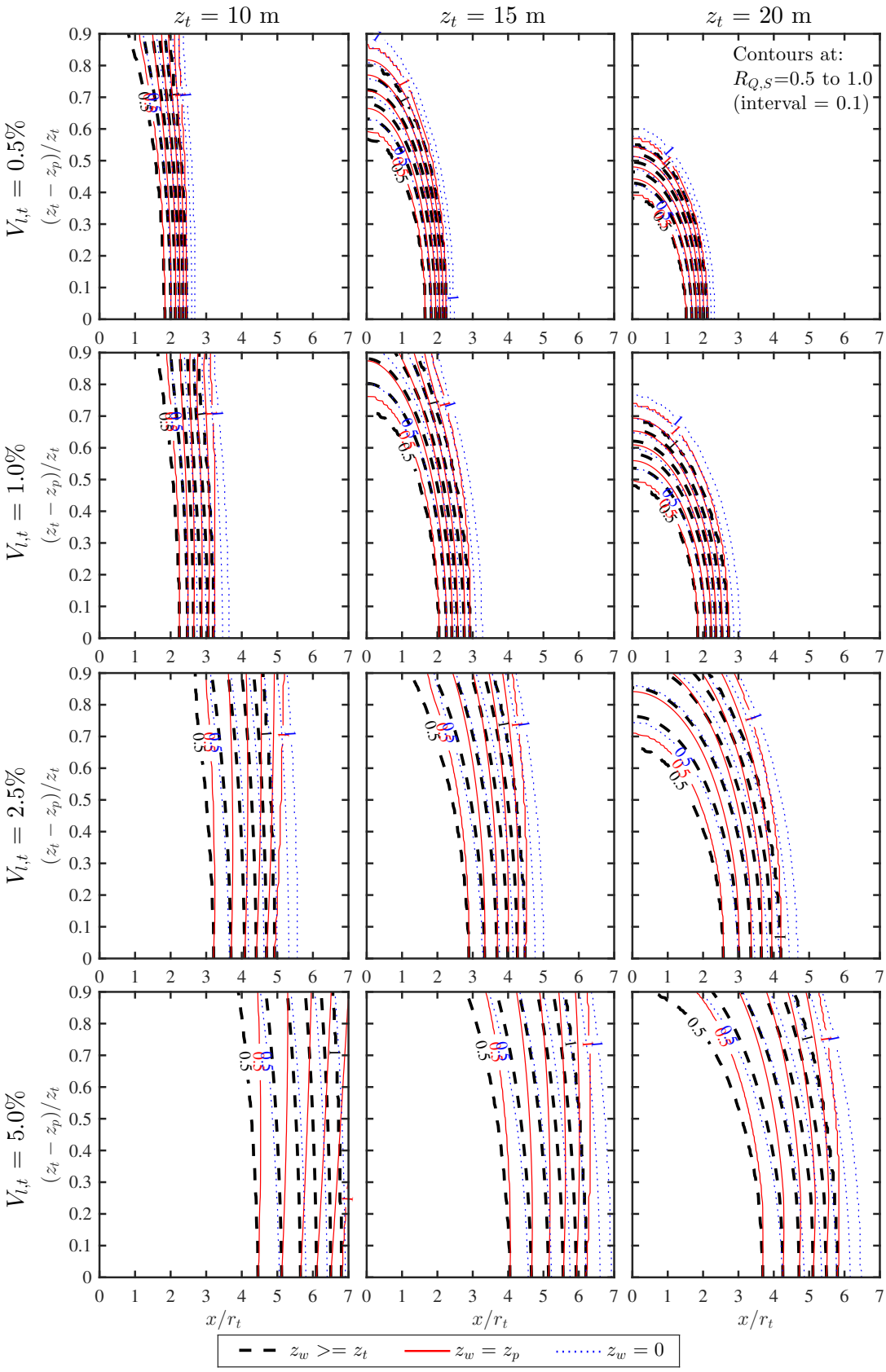

FIG. 53. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.7, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

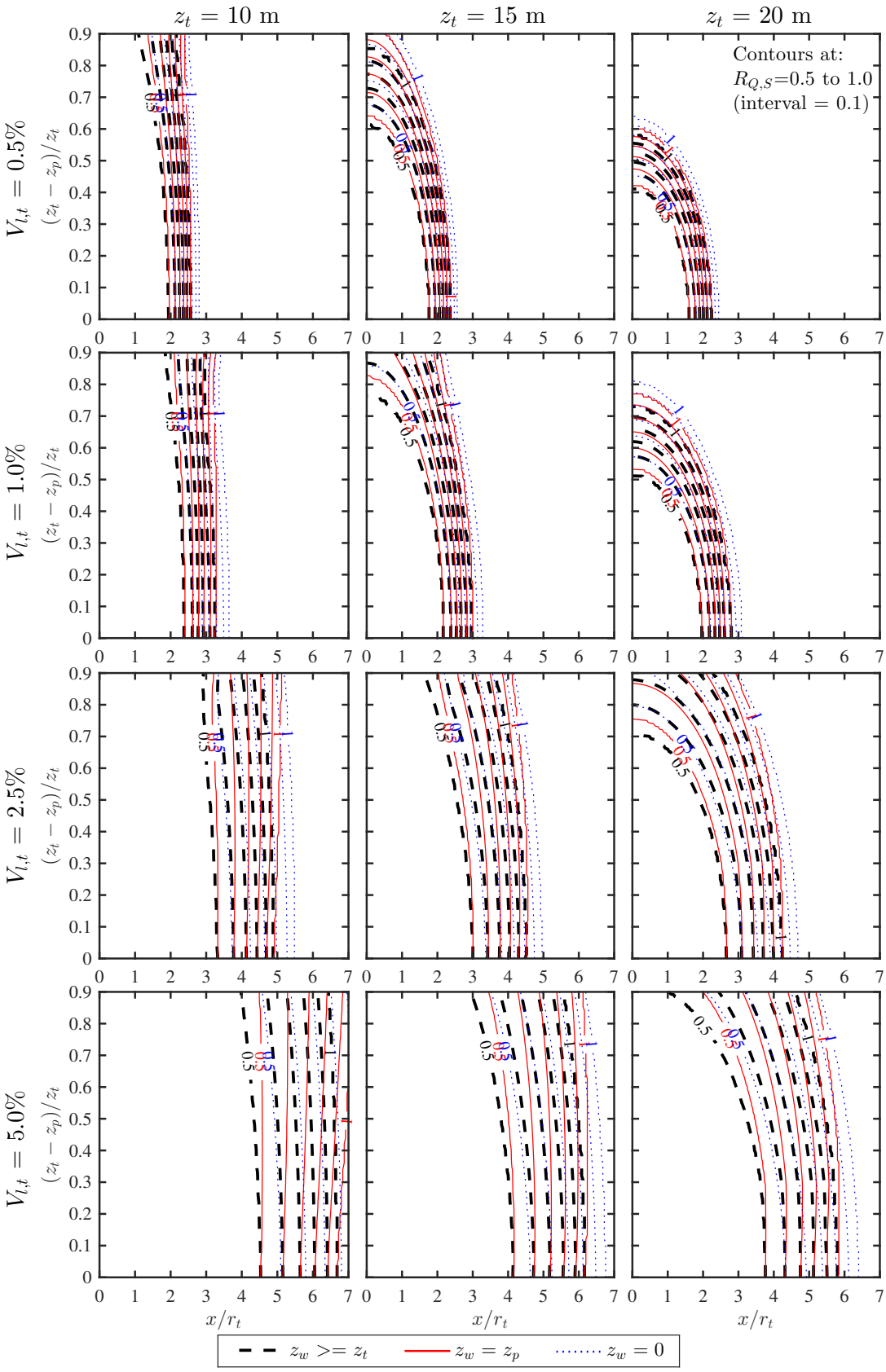

FIG. 54. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 1, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

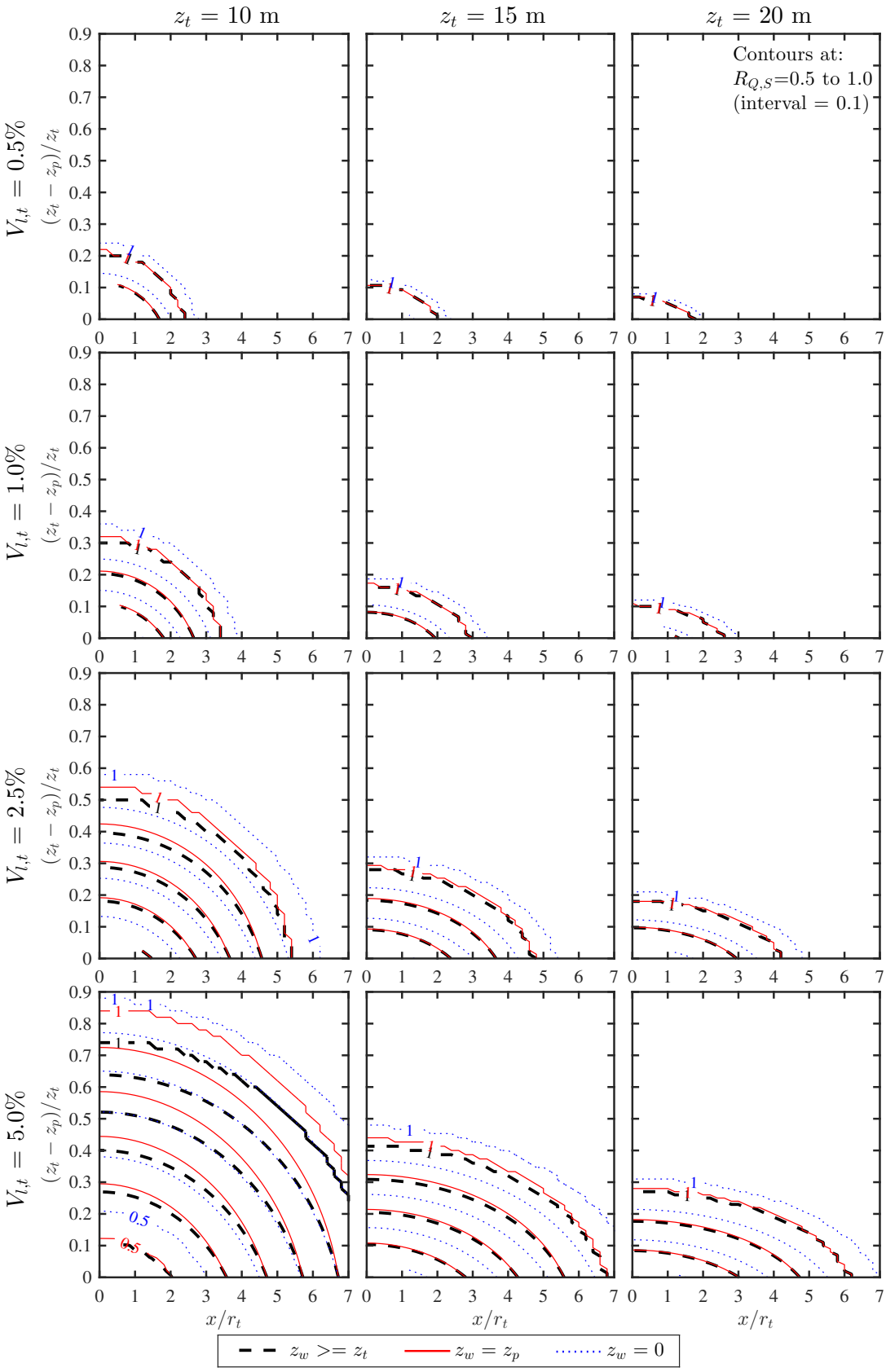

FIG. 55. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

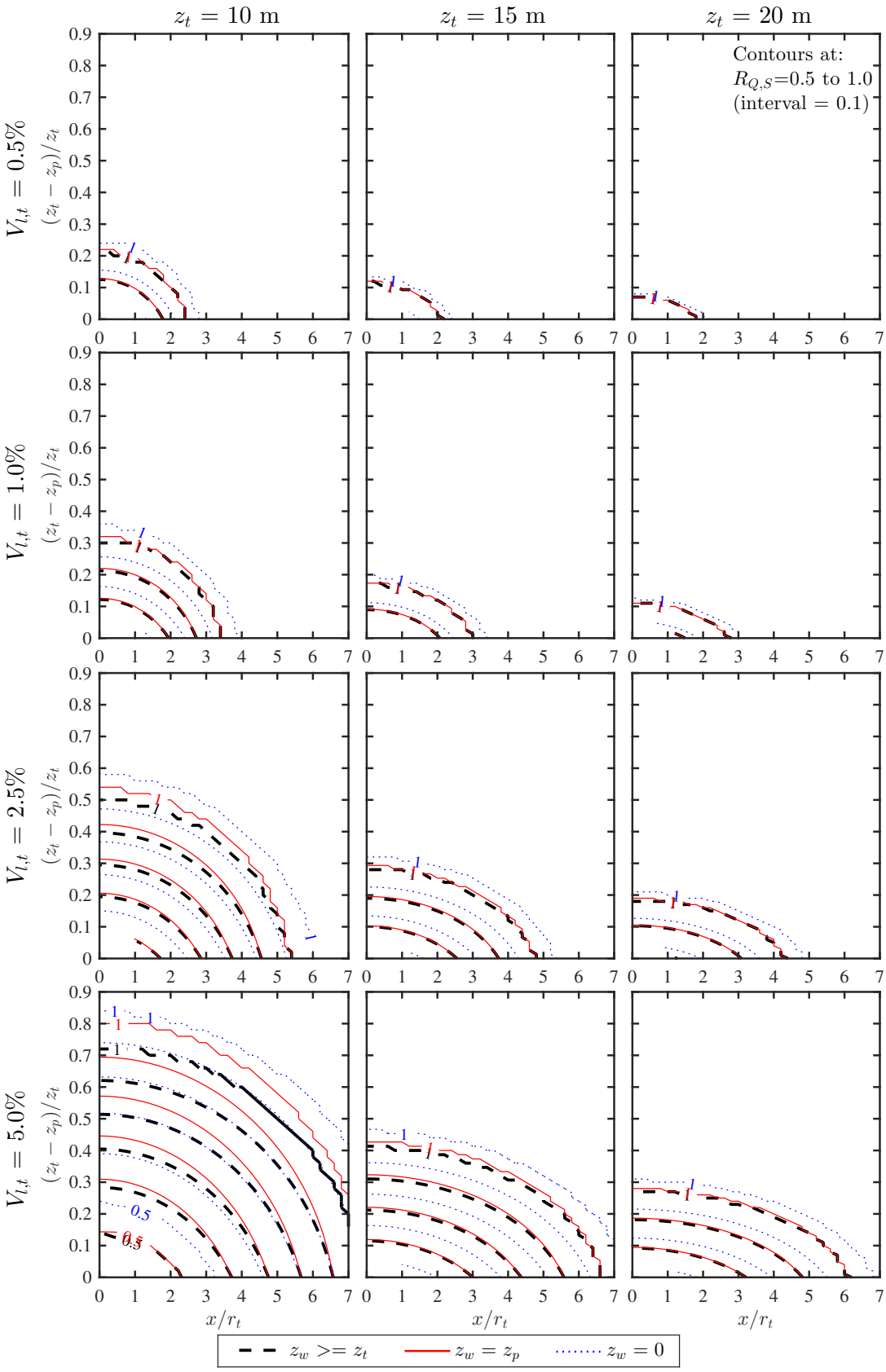

FIG. 56. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.7, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

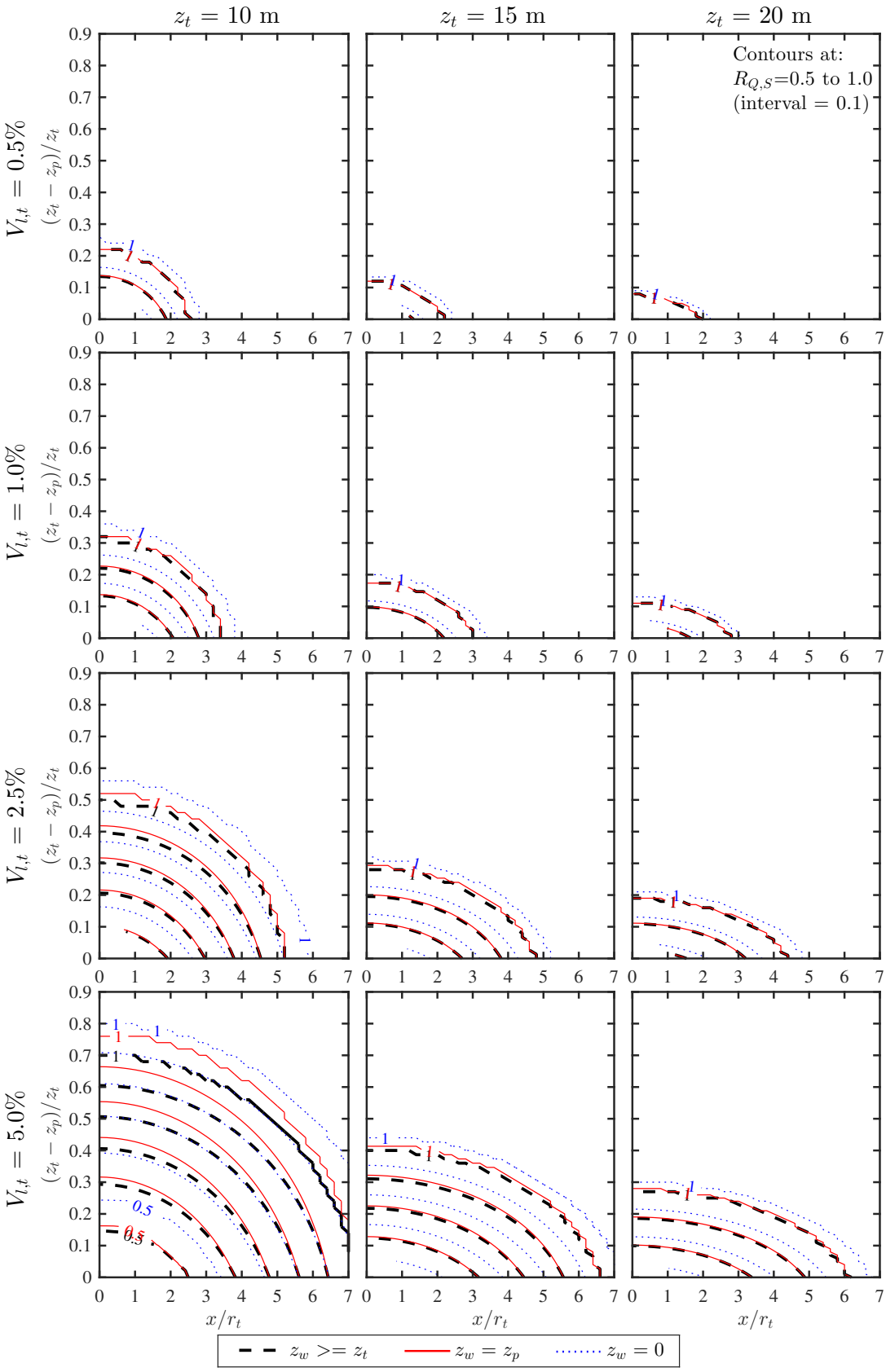

FIG. 57. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 1, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

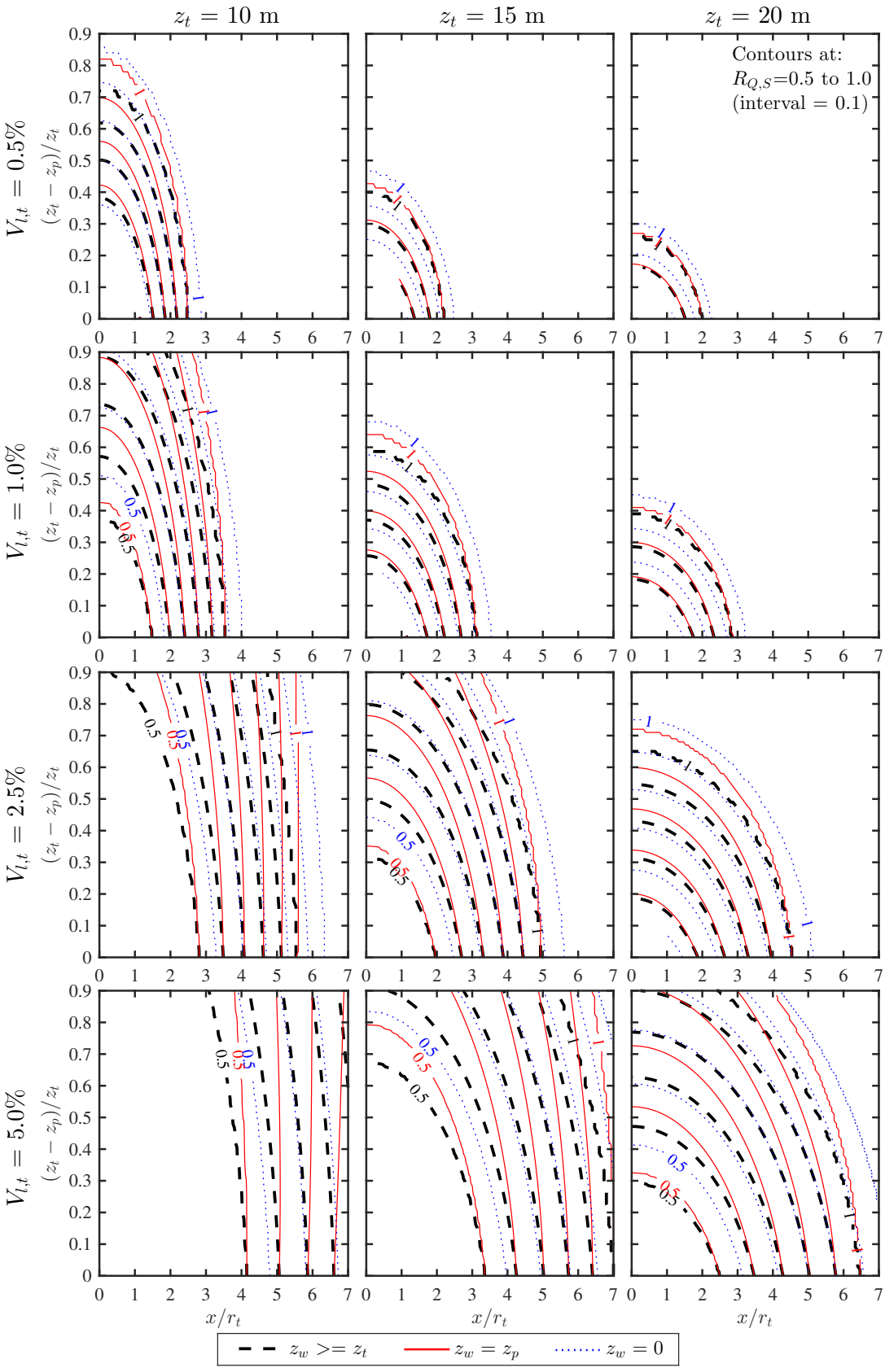

FIG. 58. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

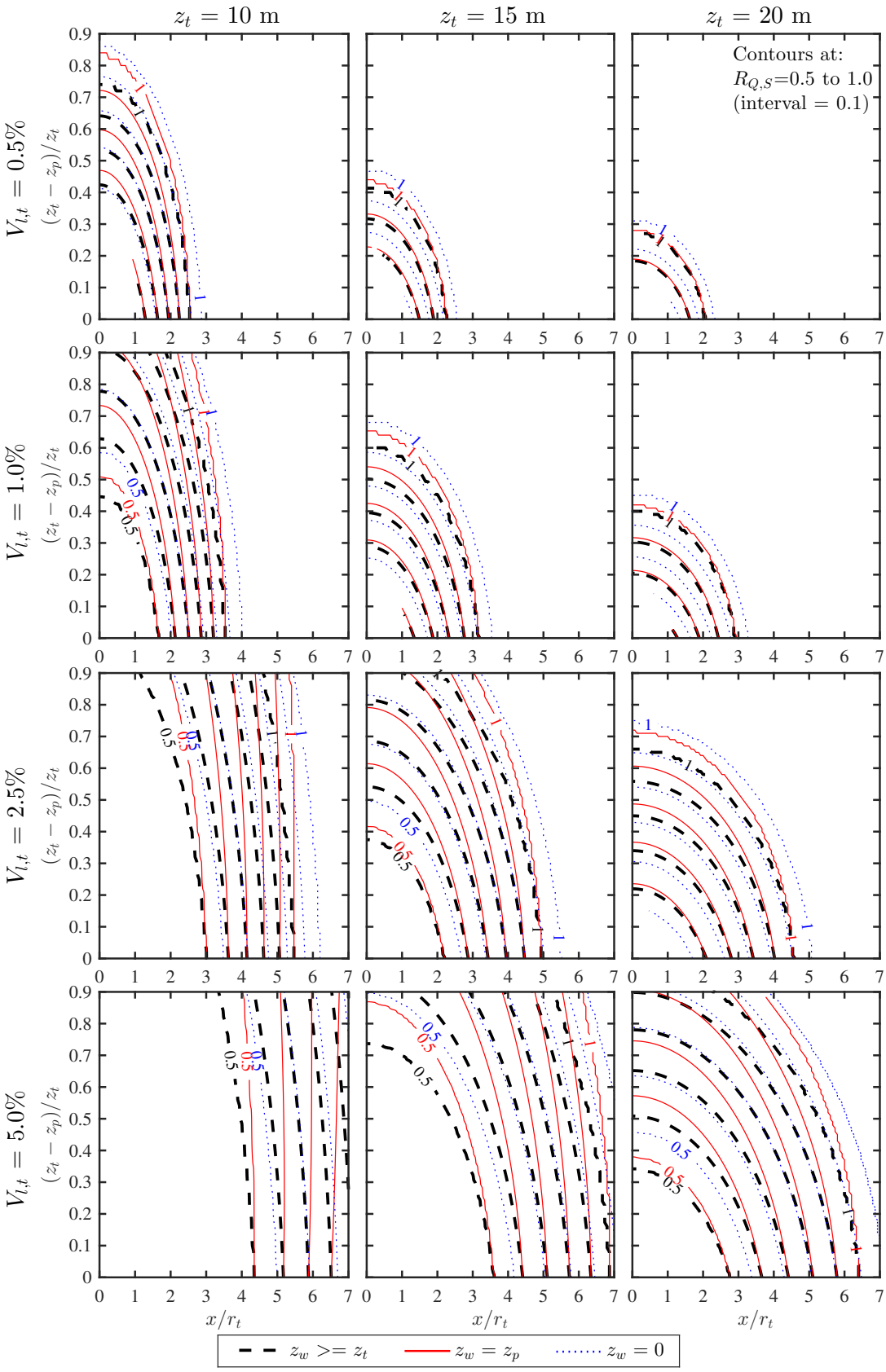

FIG. 59. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.7, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

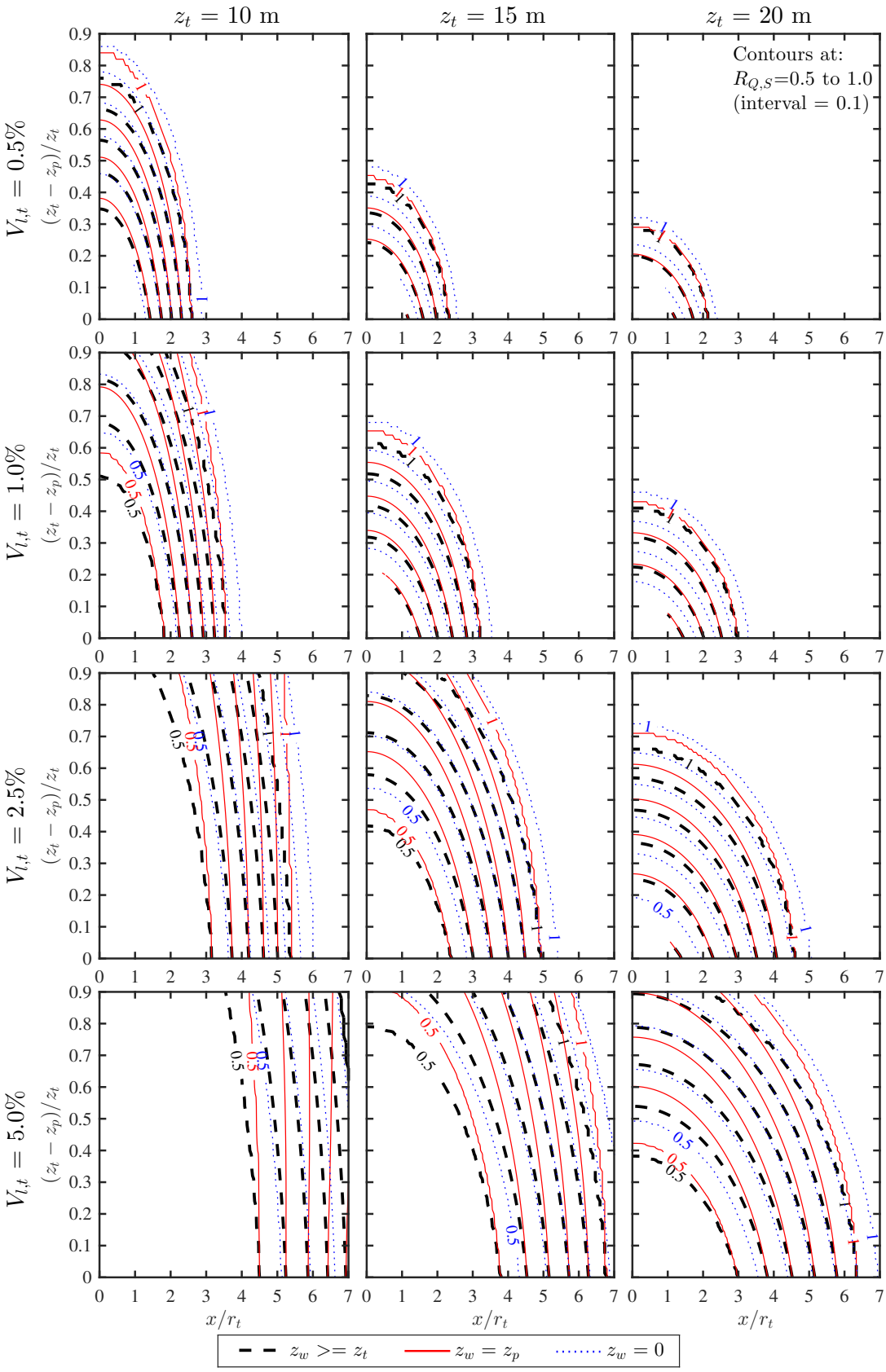

FIG. 60. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 1, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

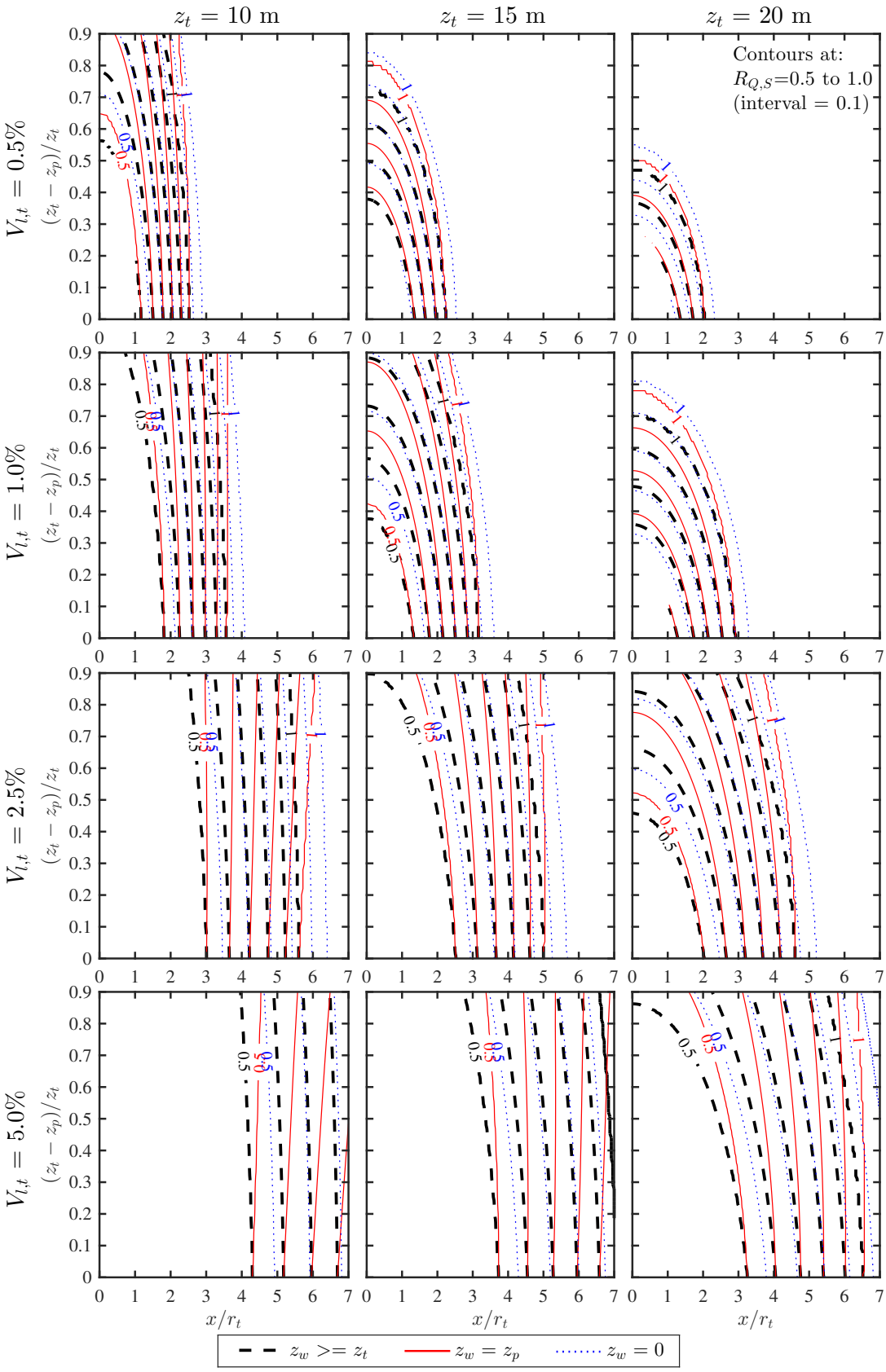

FIG. 61. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

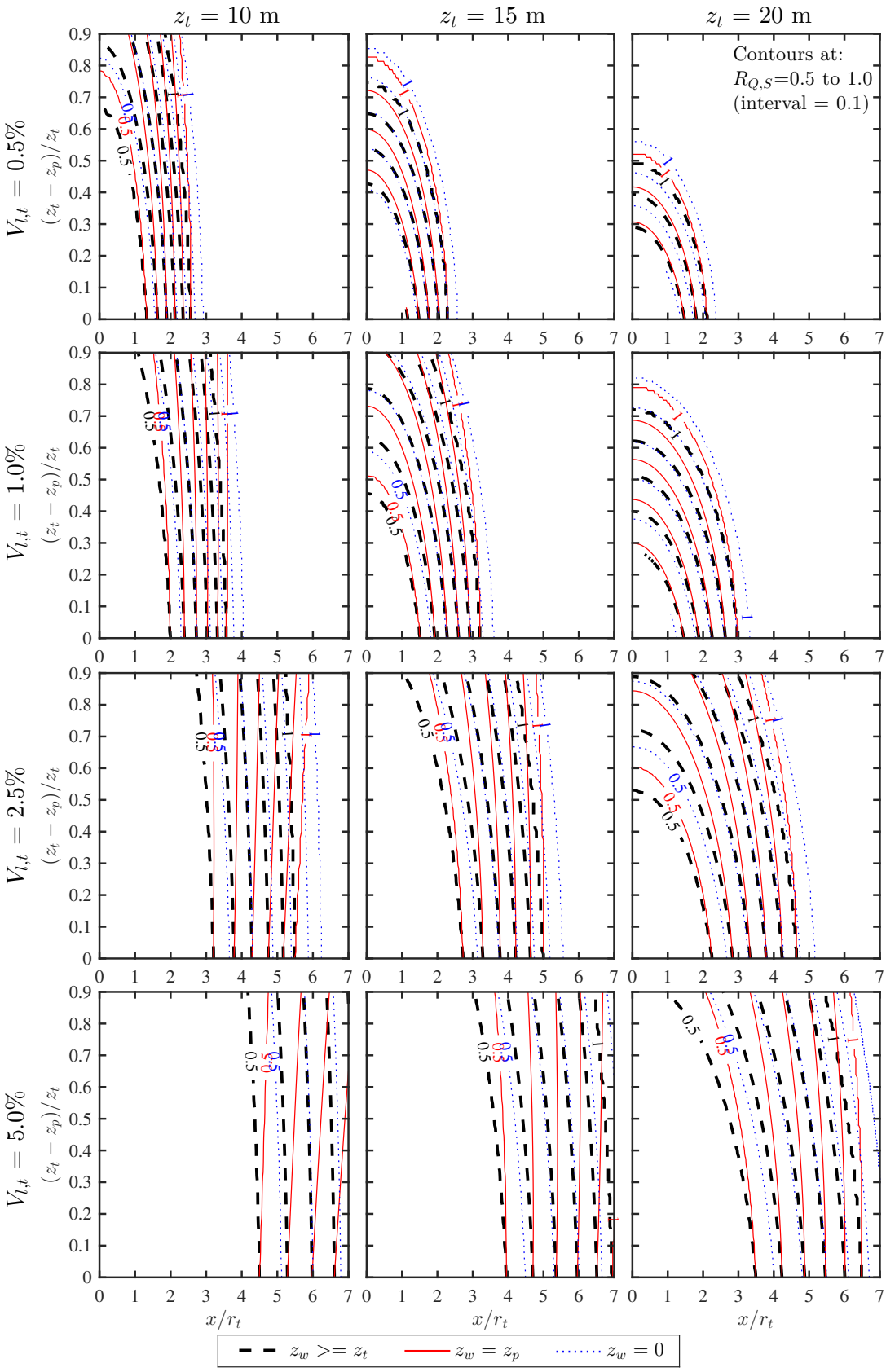

FIG. 62. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.7, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

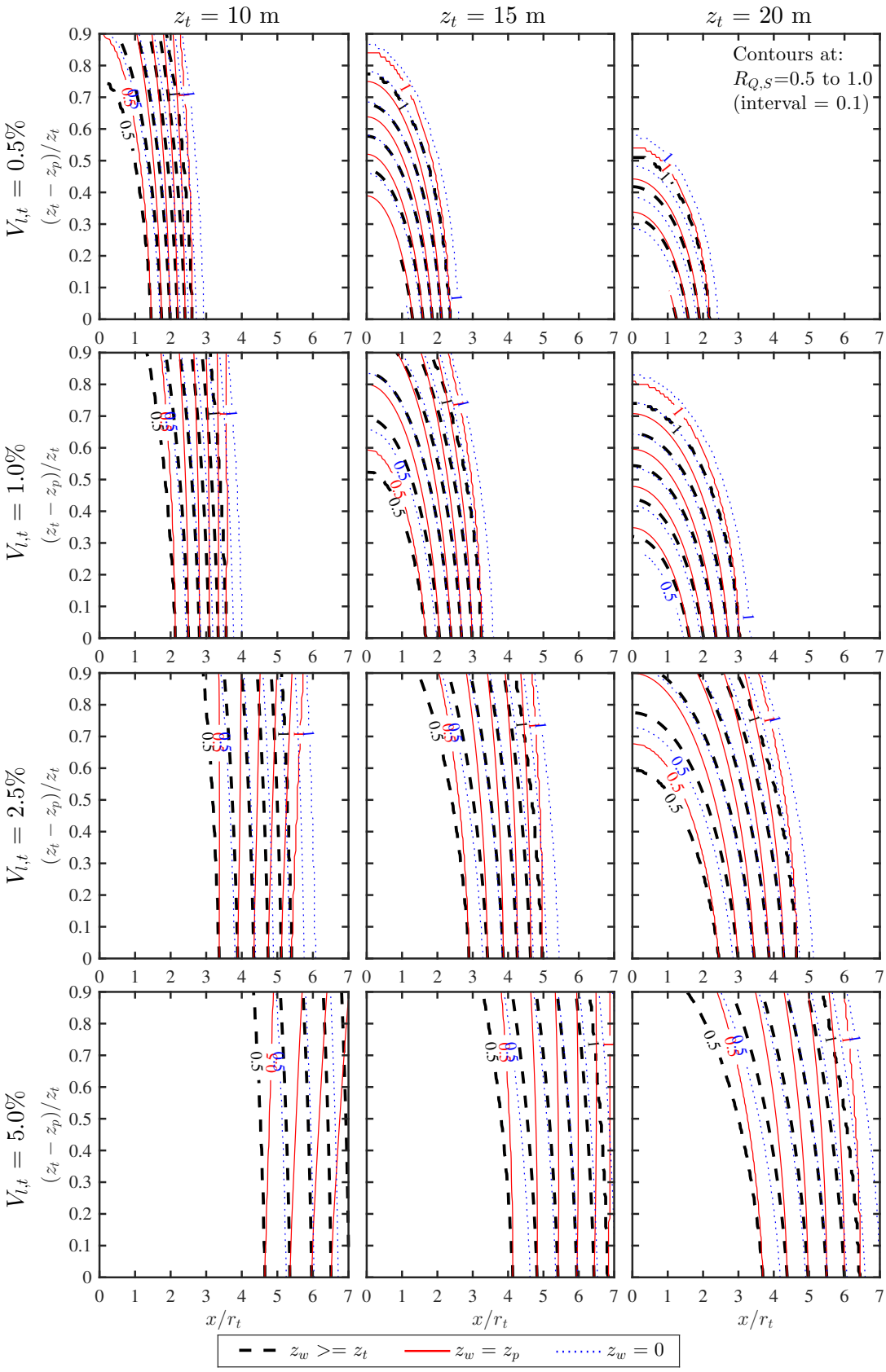

FIG. 63. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 1, ϕ'_{cv}=25°, $z_w = z_t; z_p; 0$

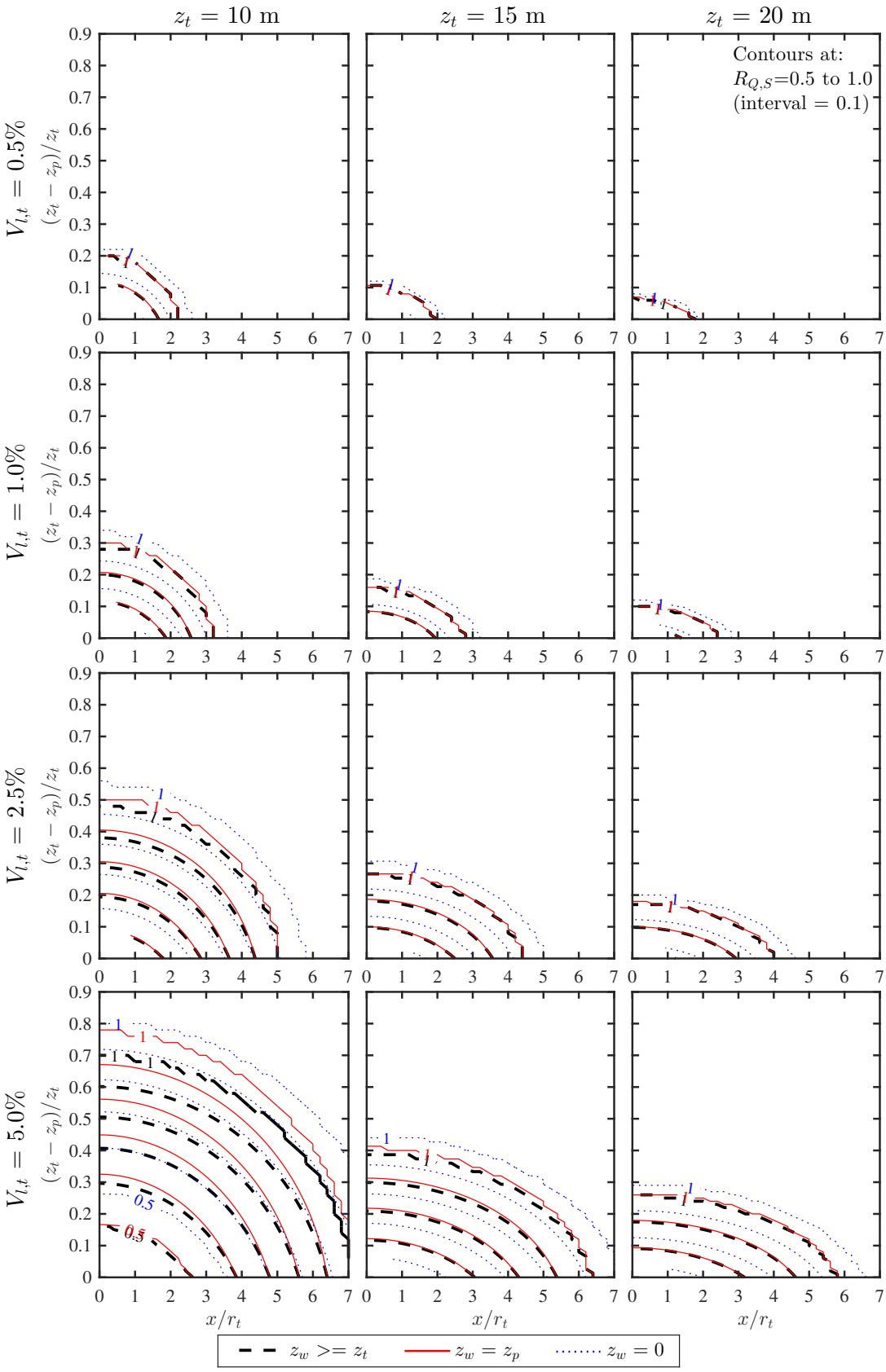

FIG. 64. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

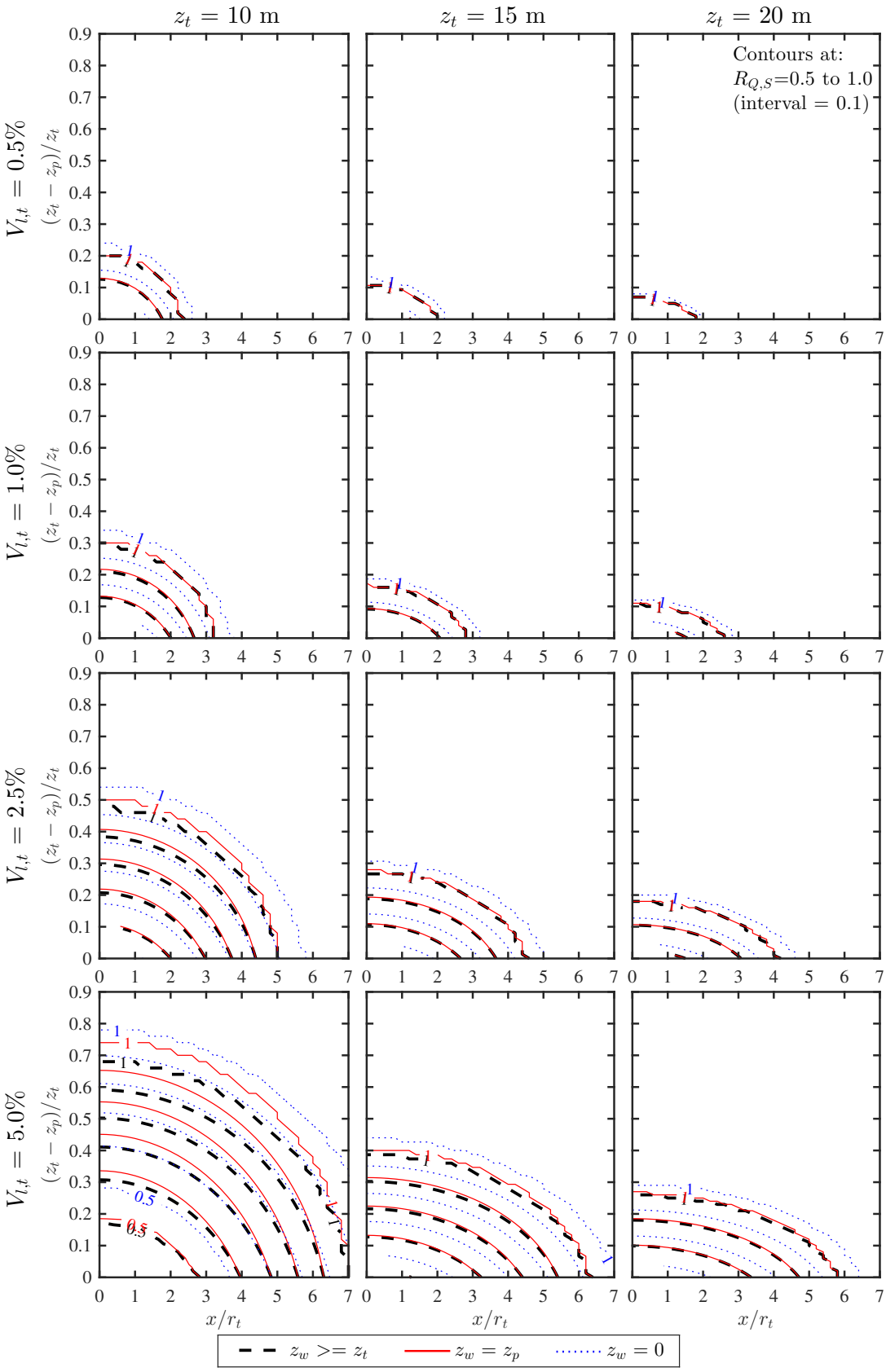

FIG. 65. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.7, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

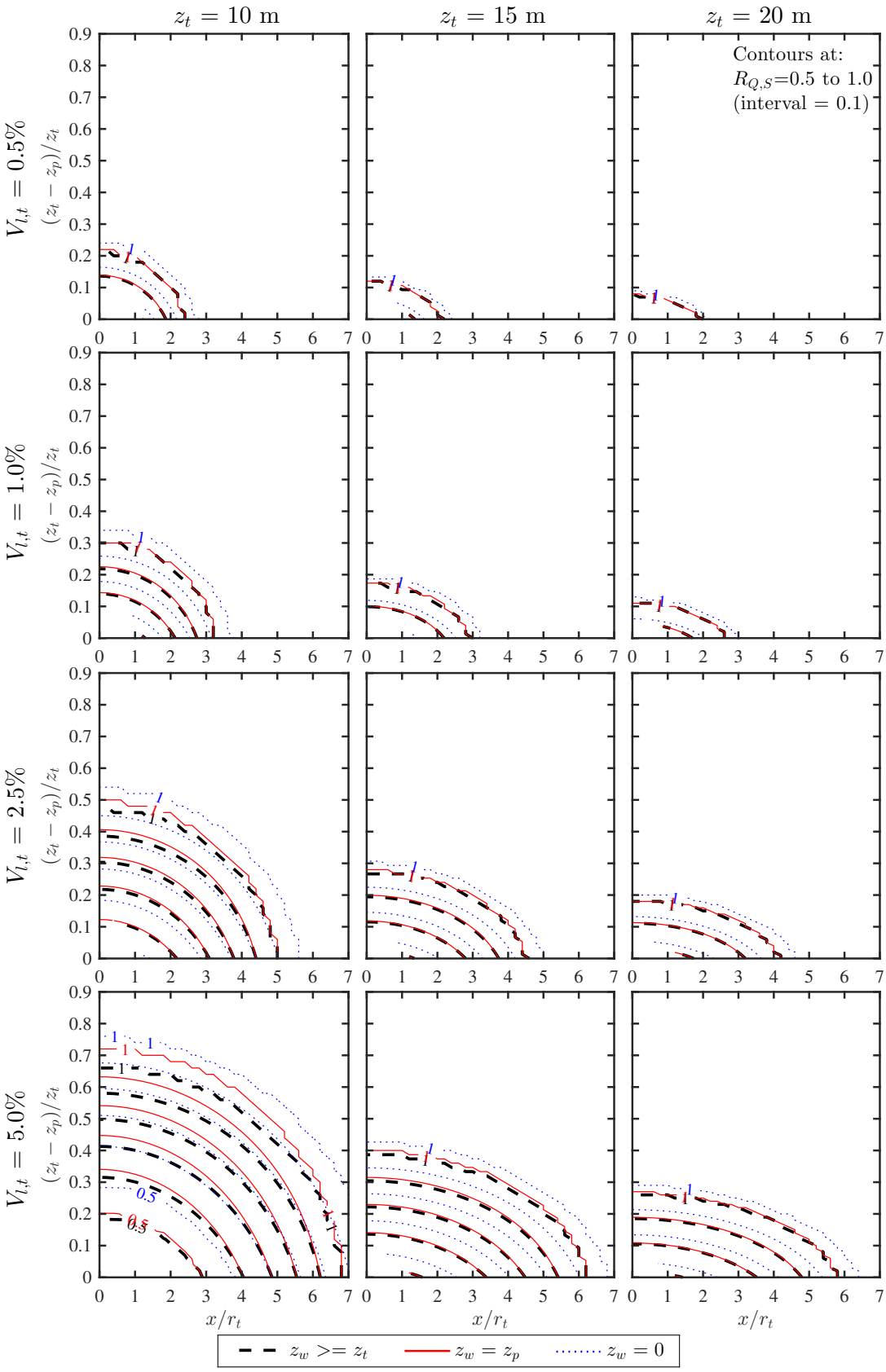

FIG. 66. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 1, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

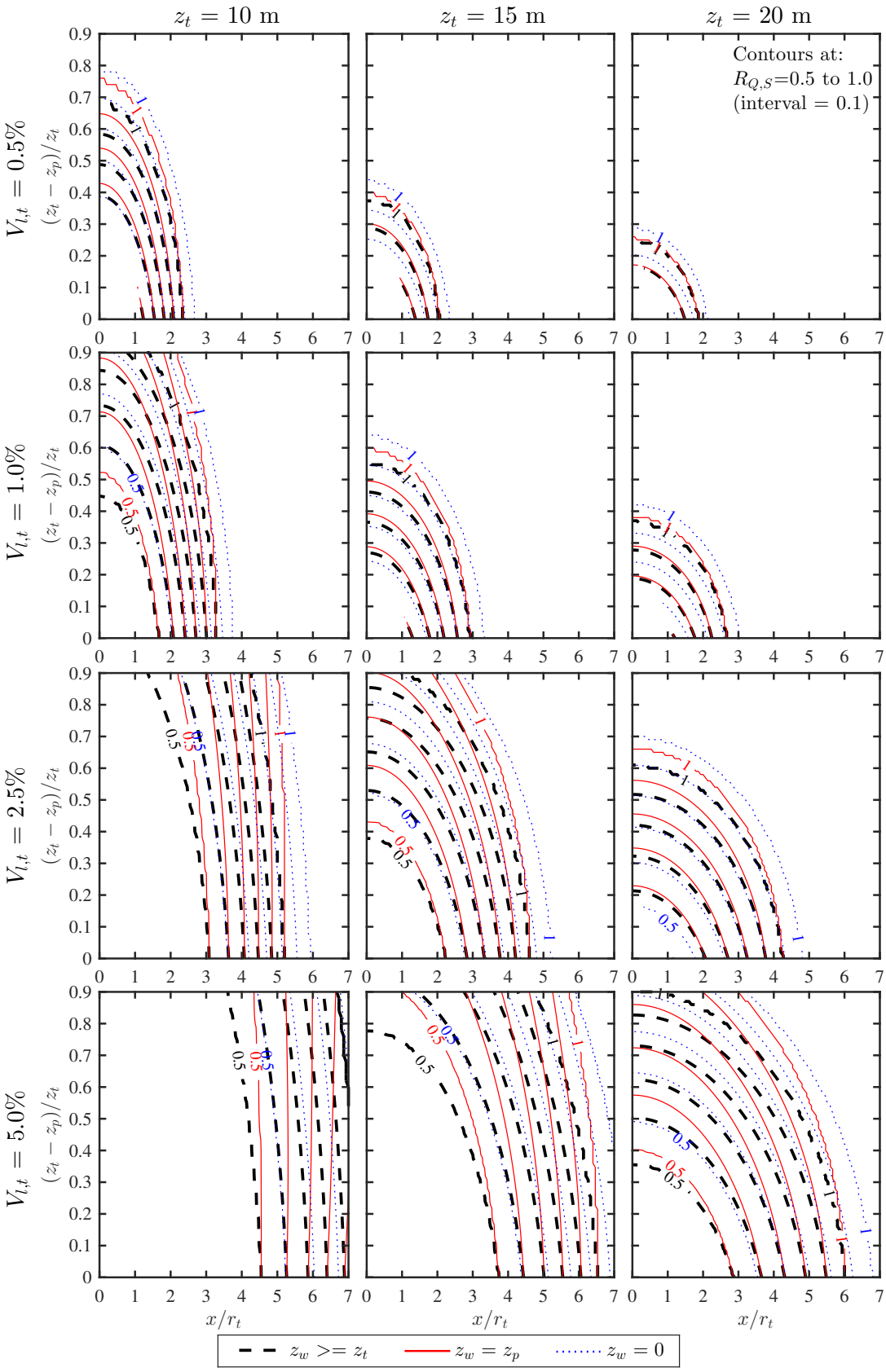

FIG. 67. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

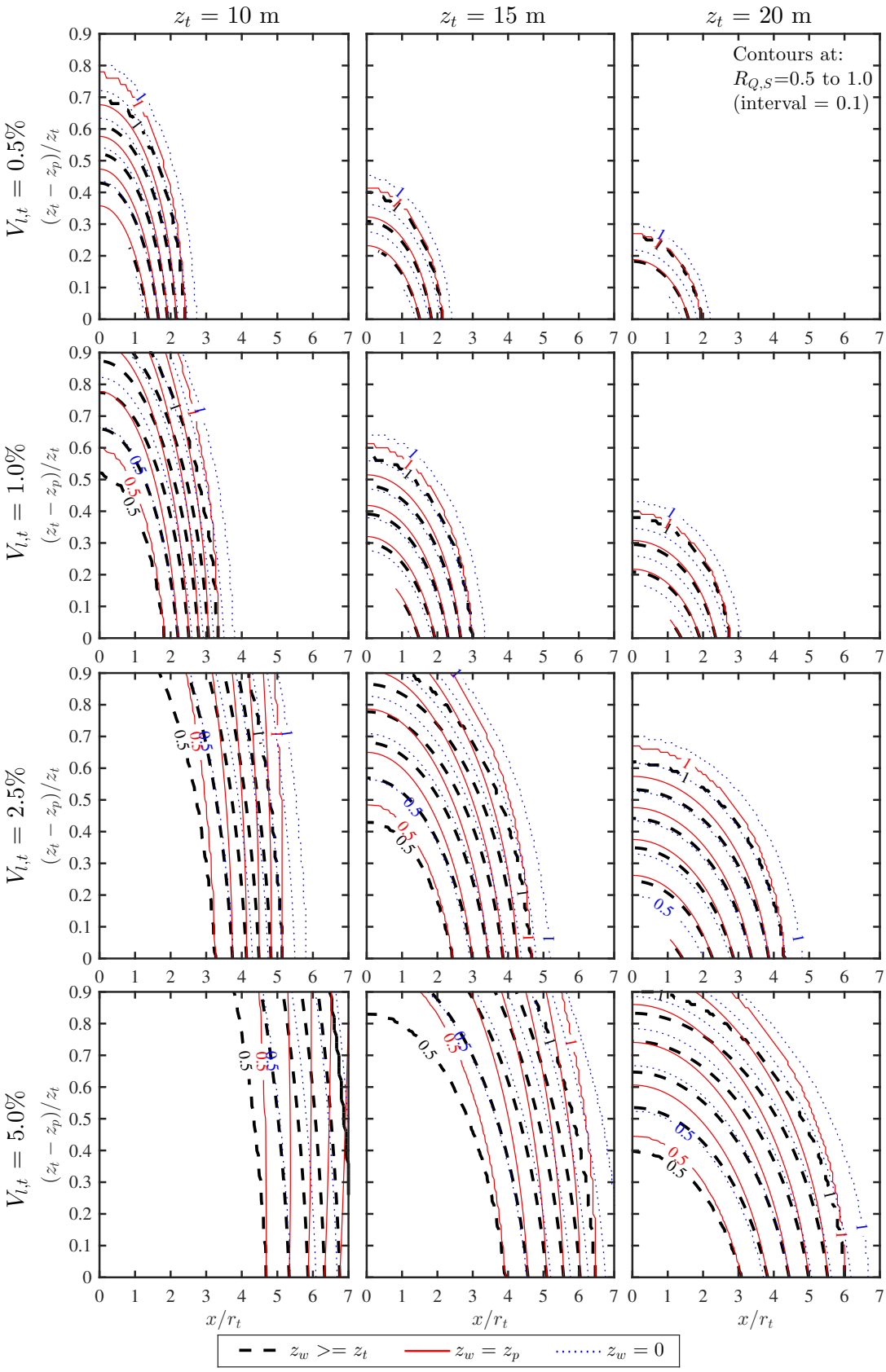

FIG. 68. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.7, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

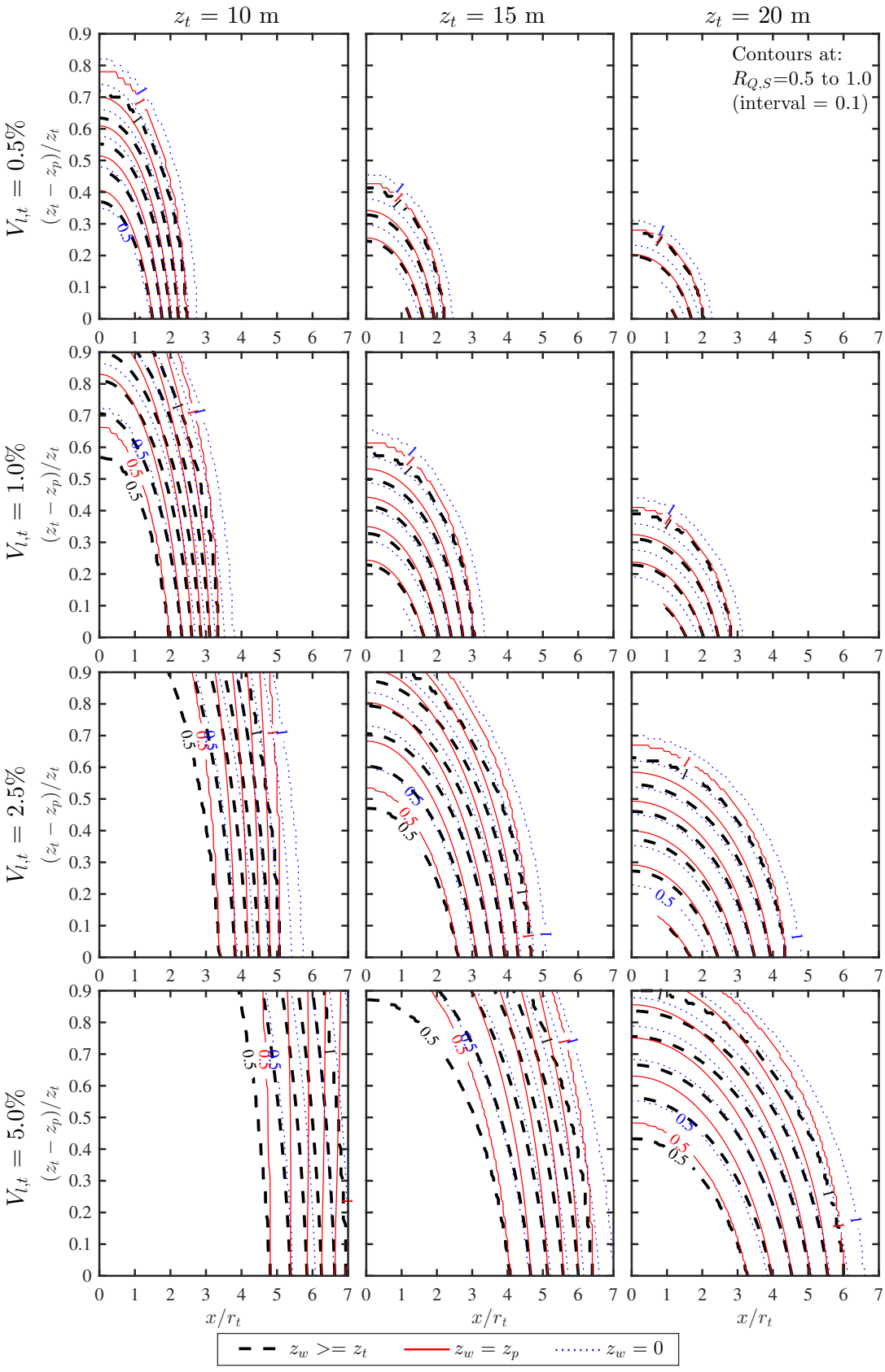

FIG. 69. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 1, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

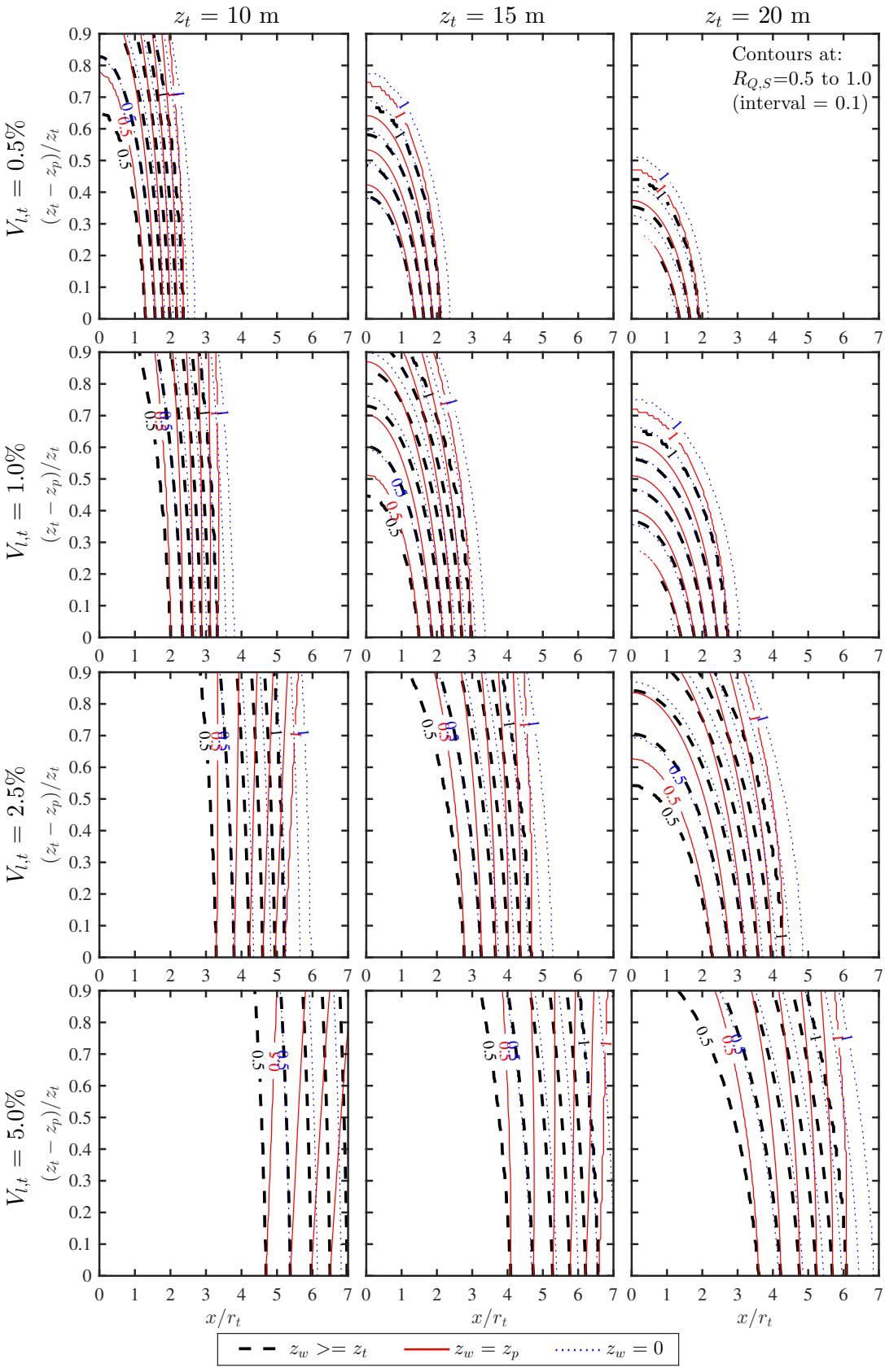

FIG. 70. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

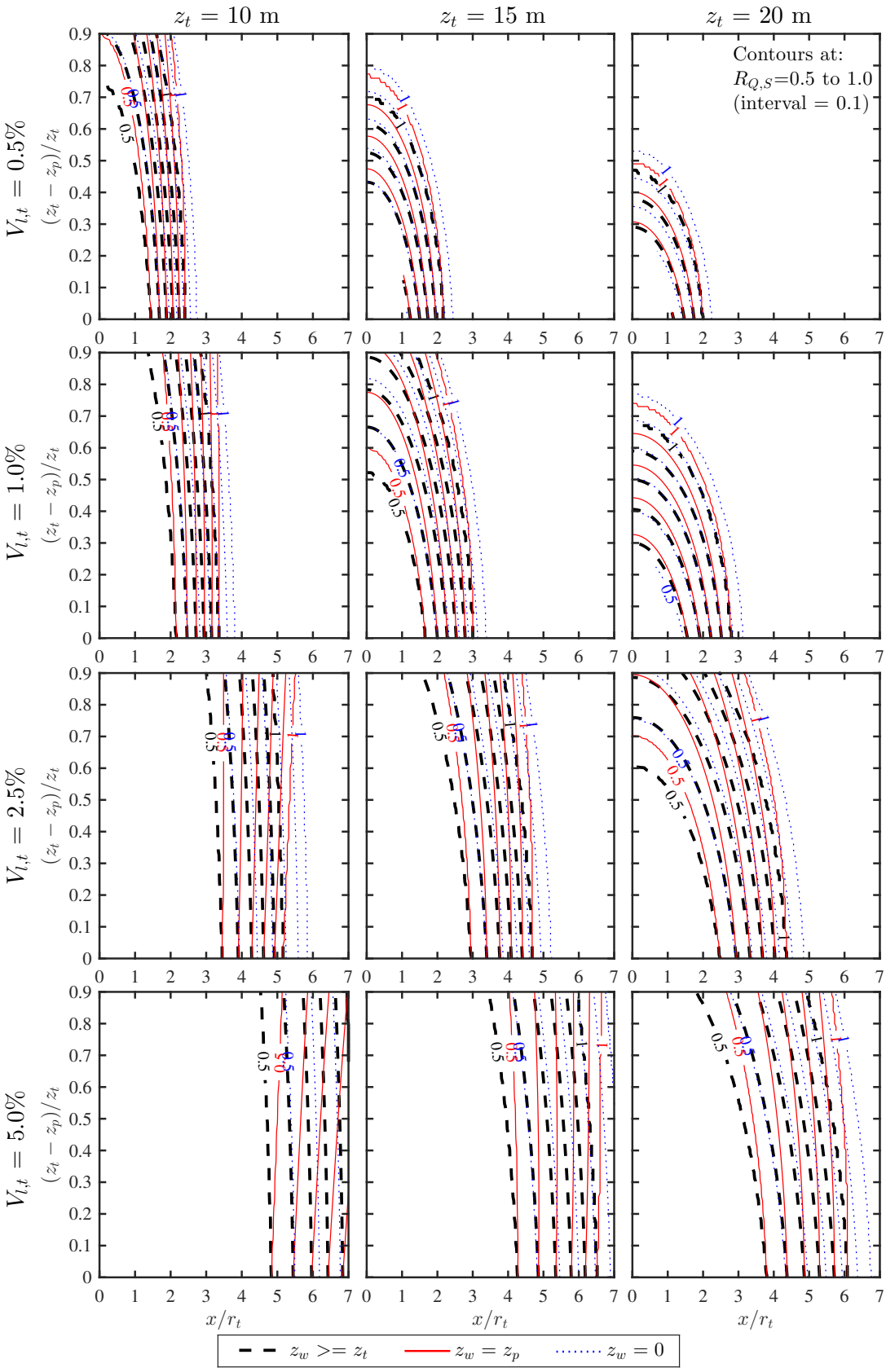

FIG. 71. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.7, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

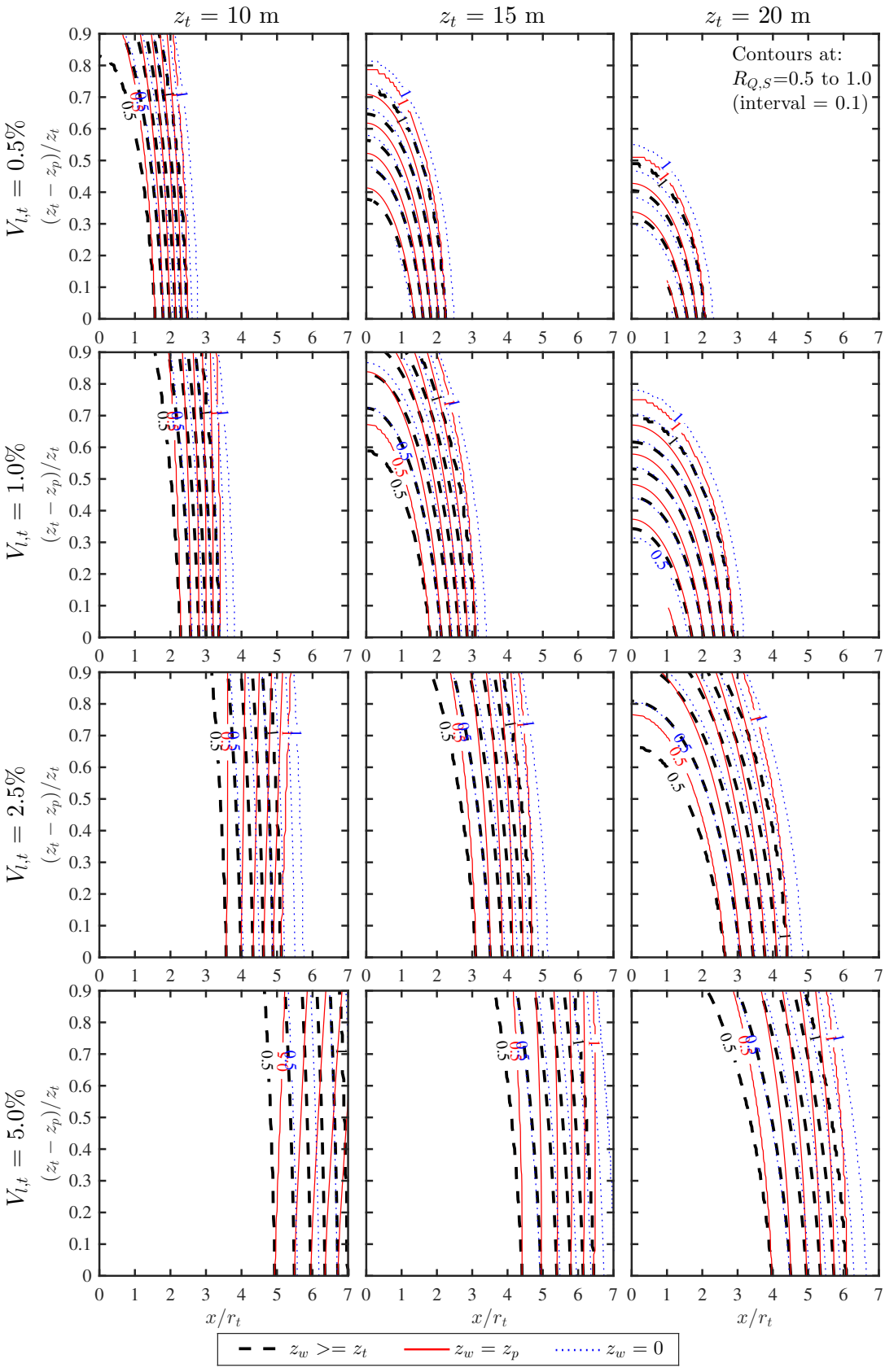

FIG. 72. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 1, ϕ'_{cv}=30°, $z_w = z_t; z_p; 0$

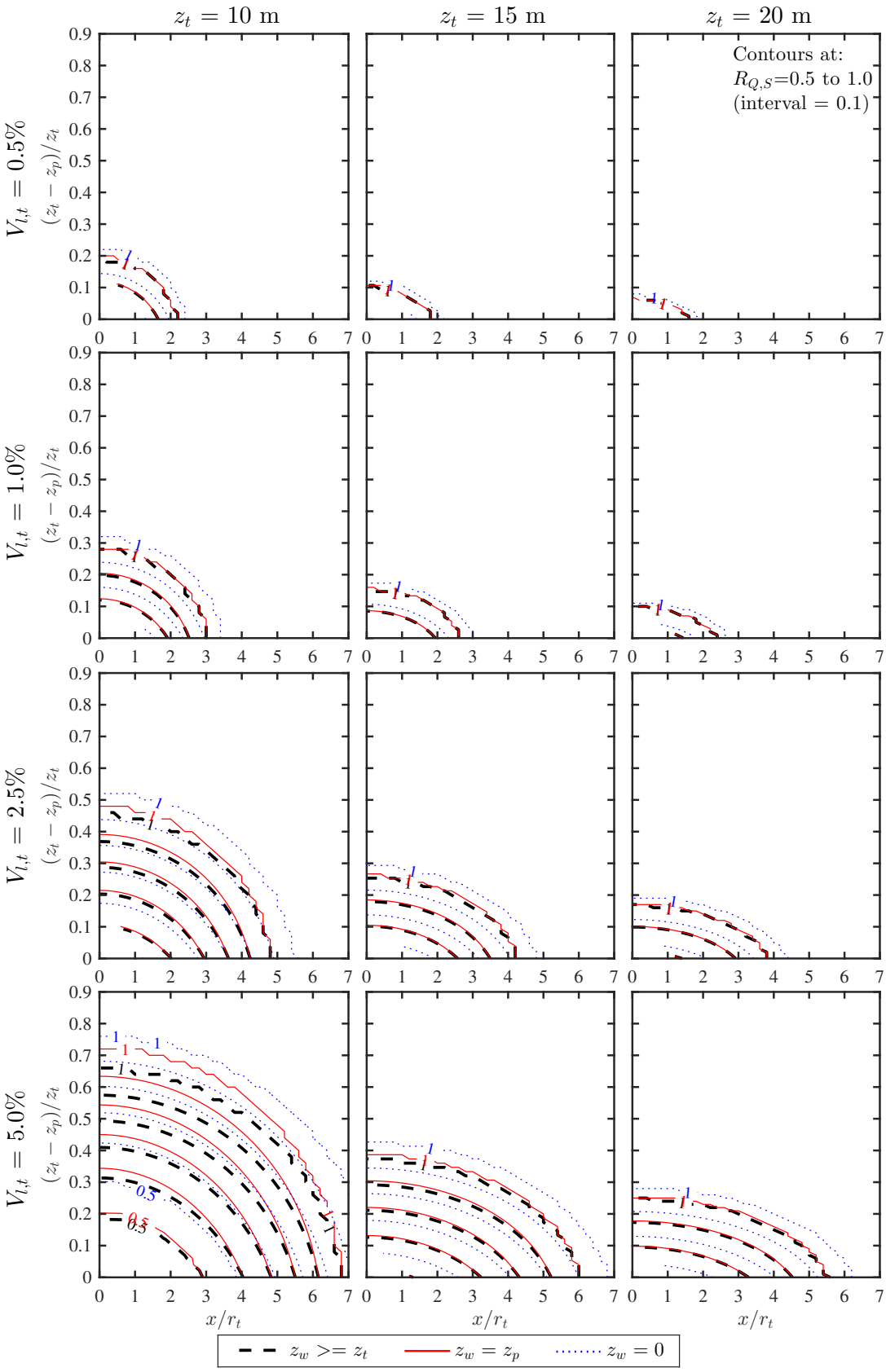

FIG. 73. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.4, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

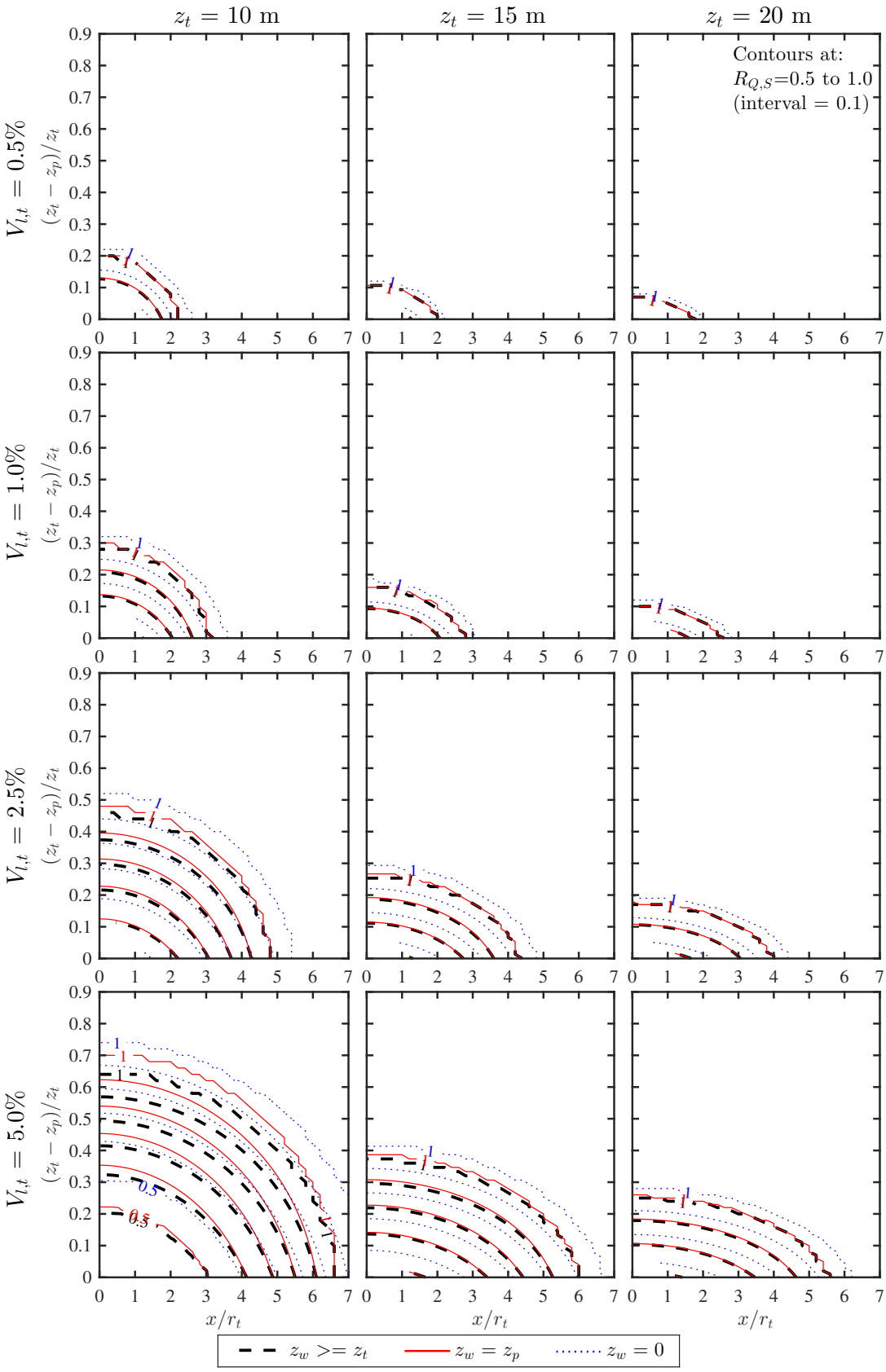

FIG. 74. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 0.7, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

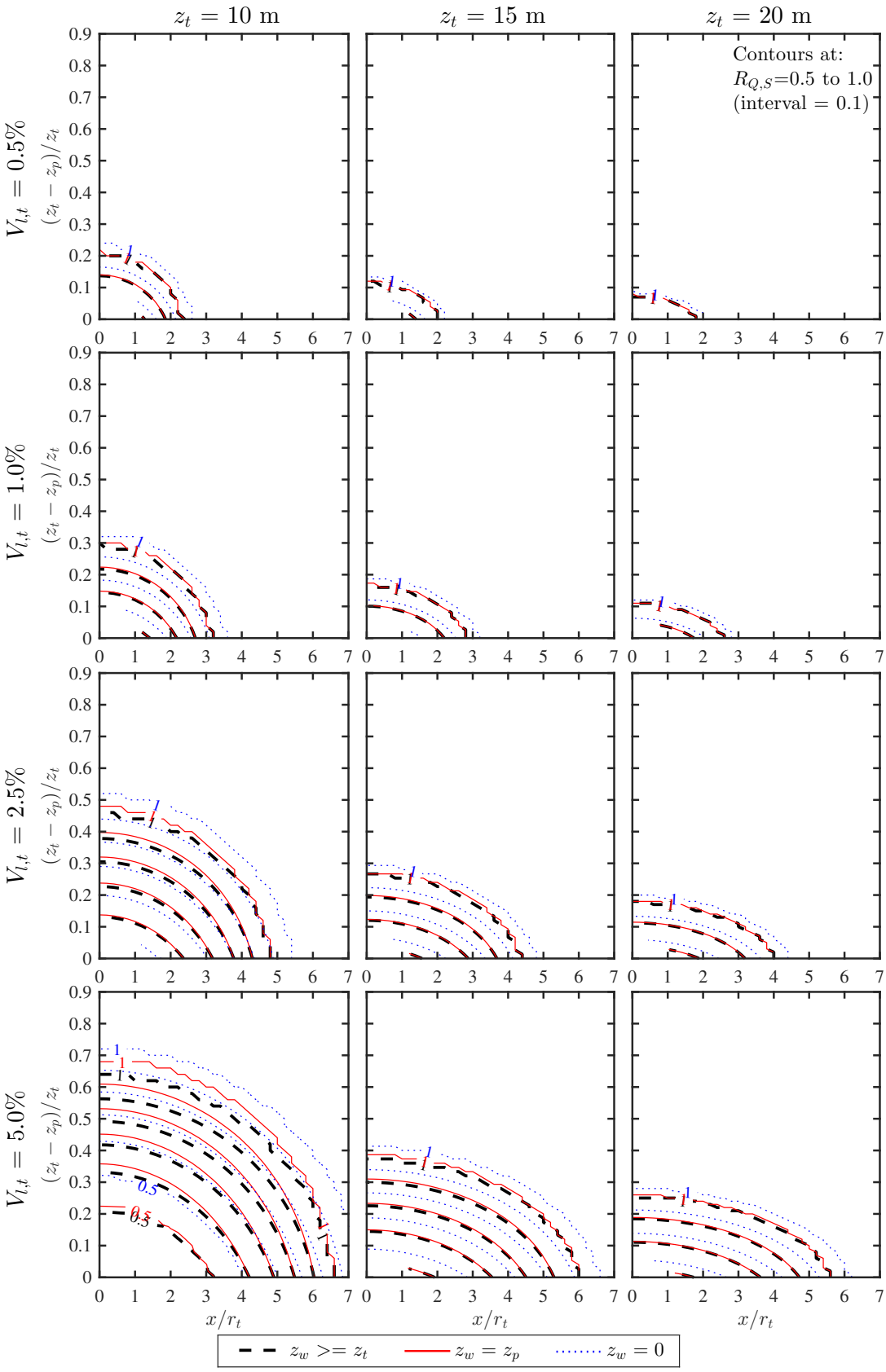

FIG. 75. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 1 m, I_d = 1, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

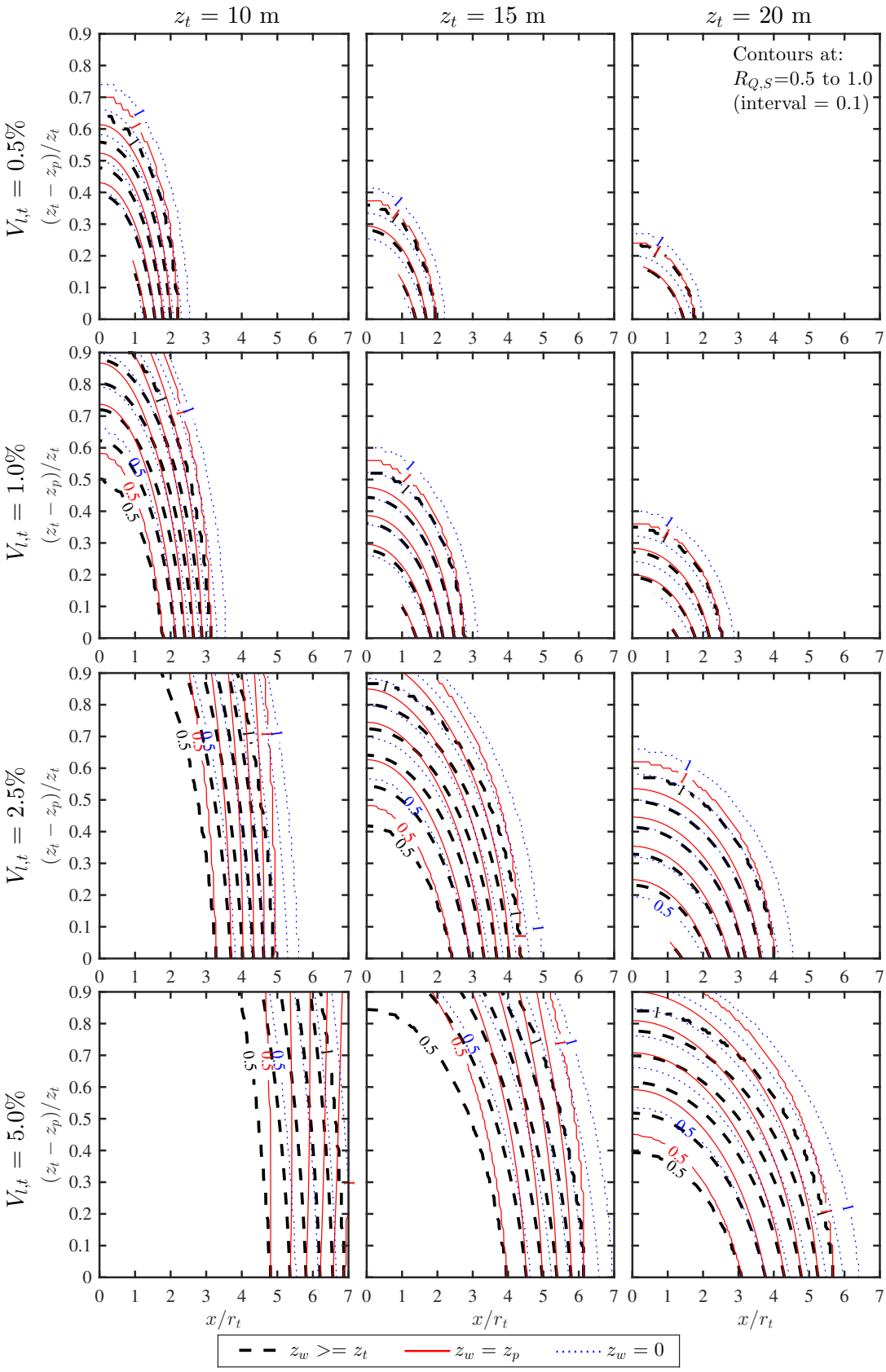

FIG. 76. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.4, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

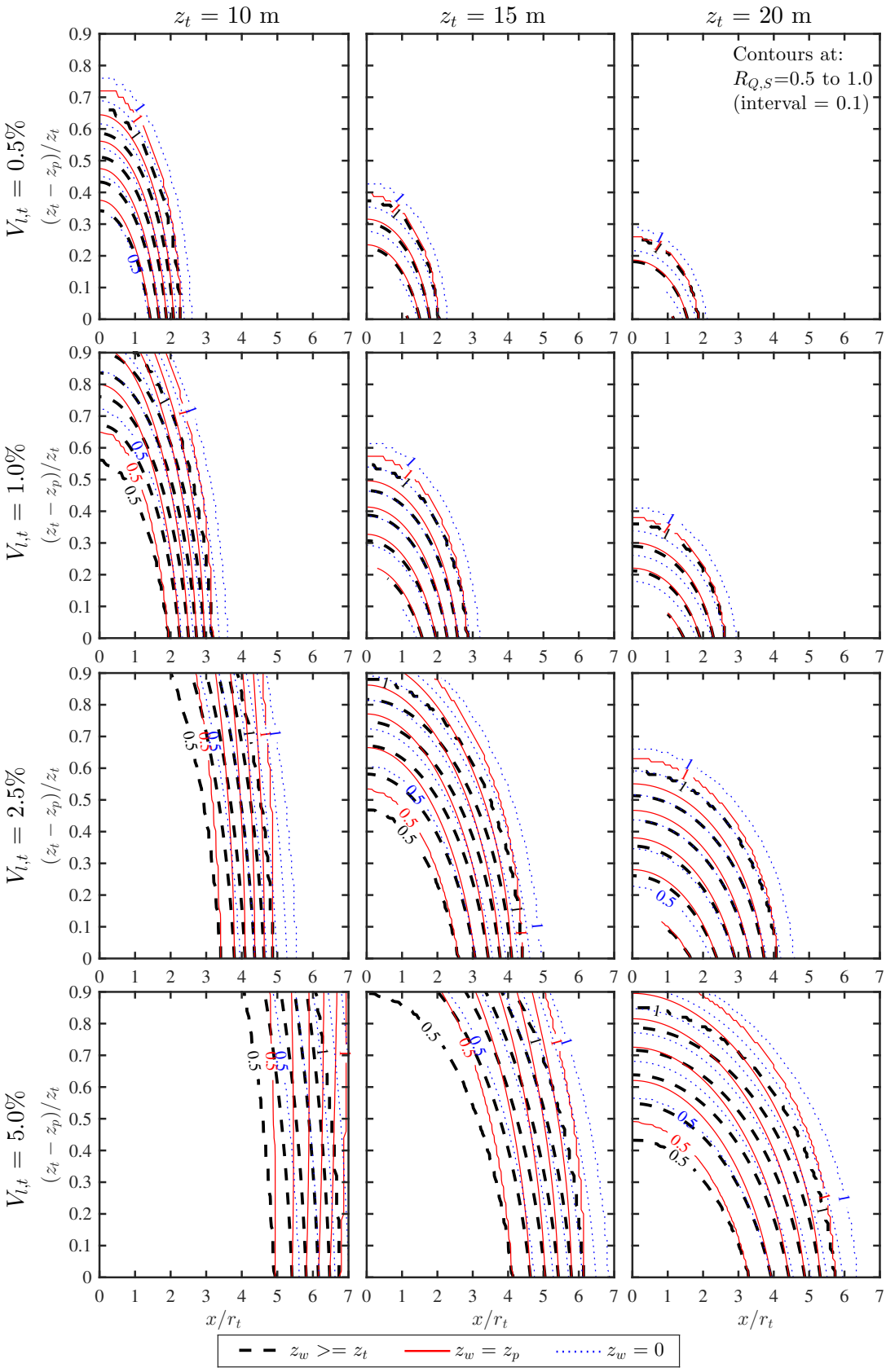

FIG. 77. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 0.7, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

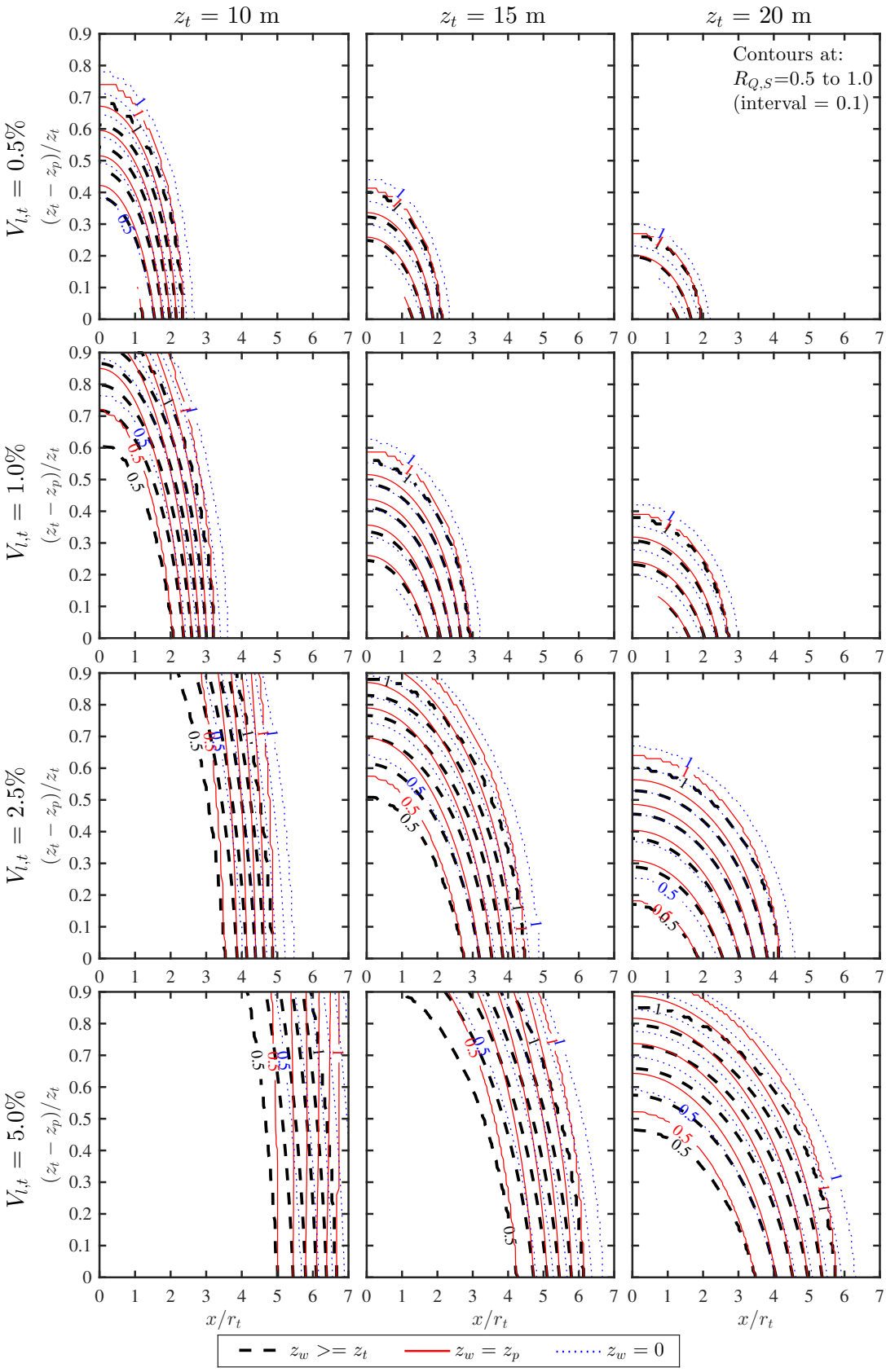

FIG. 78. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 3 m, I_d = 1, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

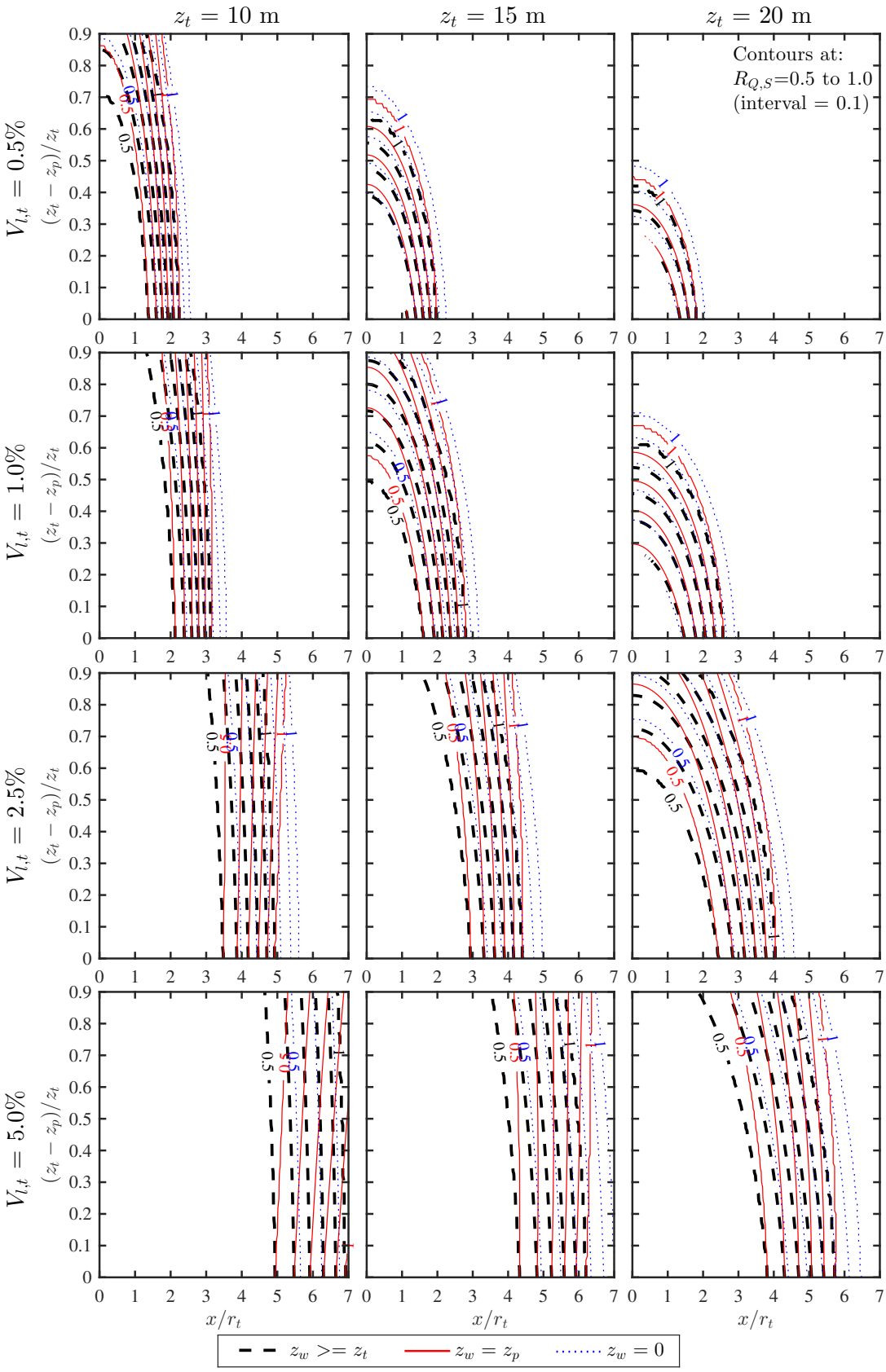

FIG. 79. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.4, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

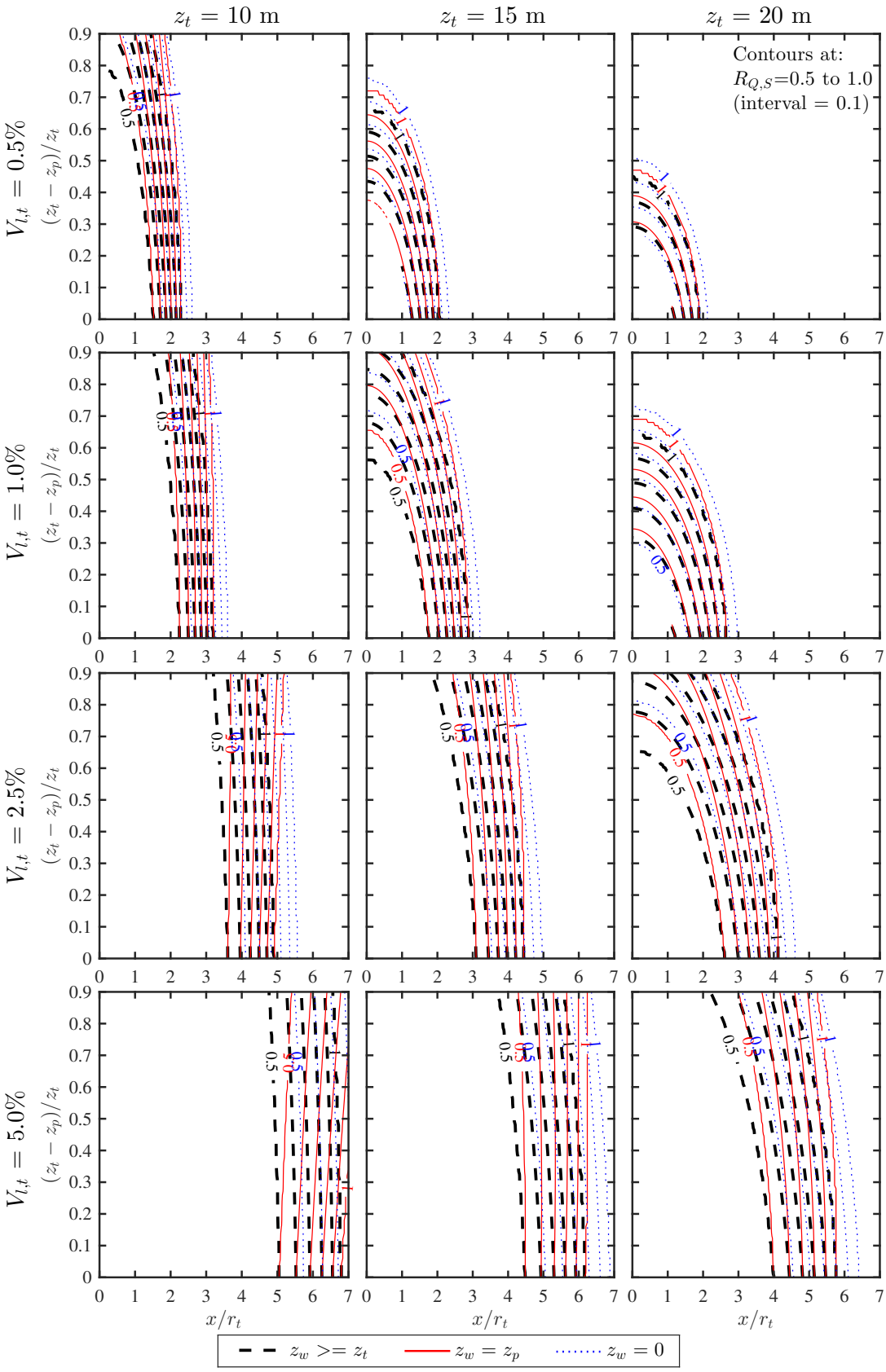

FIG. 80. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 0.7, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$

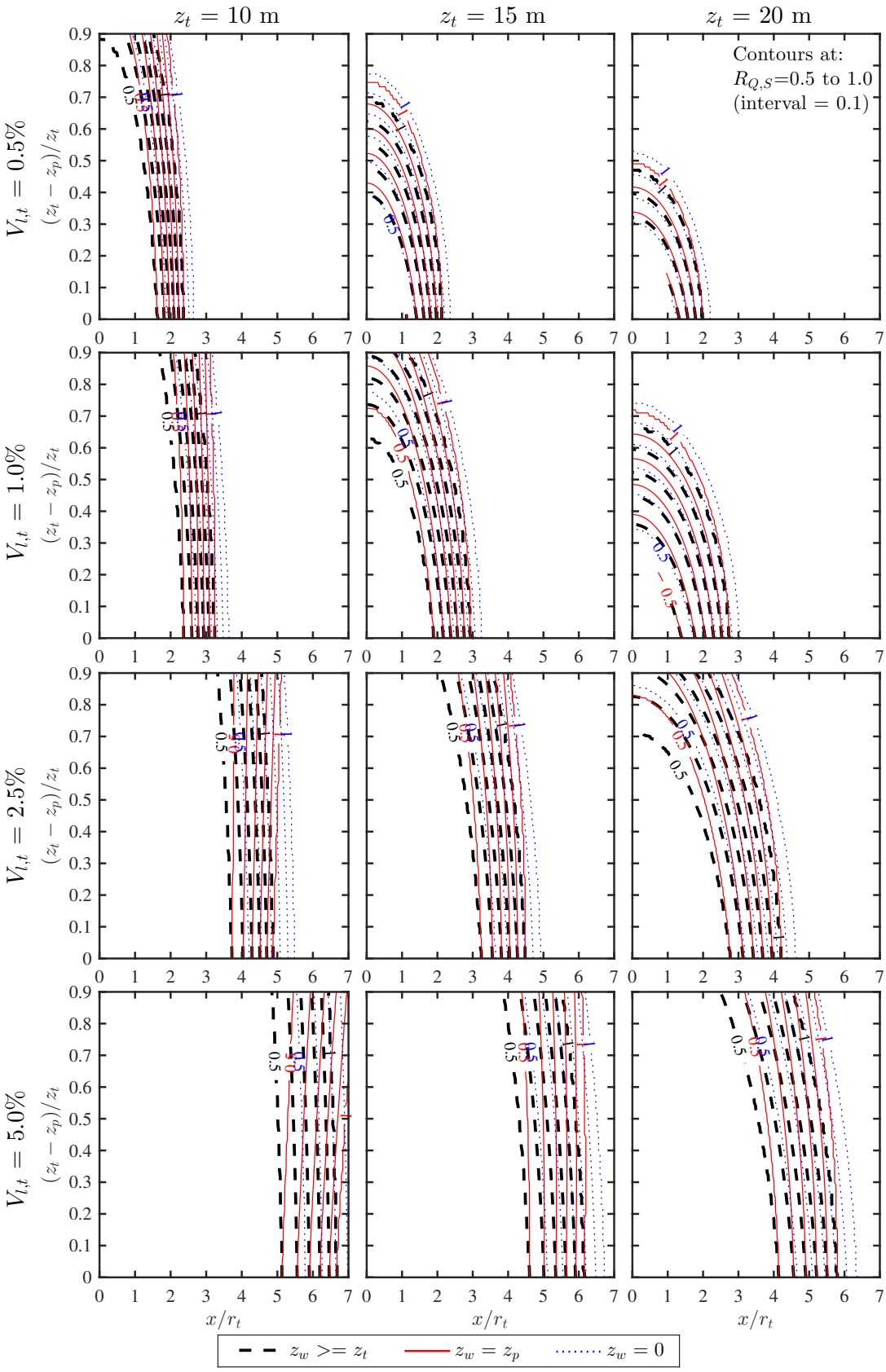

FIG. 81. Contour of $R_{Q,S}$ for non-displacement piles for: r_t = 5 m, I_d = 1, ϕ'_{cv}=35°, $z_w = z_t; z_p; 0$