

$$(1 + e)ds$$

$$\mathbf{F}(s+ds)$$

$$-F(s)$$

$$M_1(s+ds)$$

$$-M_1(s)$$

$$M_1(s)$$

$$M_2(s+ds)$$

$$-M_2(s)$$

$$-M_2(s)$$

$$M(s+ds)$$

$$-M(s)$$

$$M(s)$$

$$N(s+ds)$$

$$-N(s)$$

$$-N$$

$$-N$$



$$Q(s+ds)$$

$$-Q(s)$$

$$S(s)$$

$$\overline{S}(s)$$

$$T_1(s+ds)$$

$$-T_1(s)$$

$$-T_1(s)$$

$$T_2(s+ds)$$

$$-T_2(s)$$

x_1

X_2

arc tangent

arc

tangent

on

on

beam tangent

d_1

d_1^*

d_1

d_1

d_1^\perp

d_1

\overline{d}_1

\overline{d}_1

d_2

d_2^*

d_2^\perp

d_2

d_2^\perp

d_2

\overline{d}_2

d_3

\overline{d}_3

$$d\theta = \kappa ds$$

$$d\theta_1 = \kappa_1 ds$$

$$d\theta_2 = \kappa_2 ds$$

$$d\theta_3 = \tau ds$$

ds

e_0

e_1

$$e_{2i+1}$$

$$e_{2i-1}$$

$$e_{2i-2}$$

e_{2i}

$$e_{i+1}$$

$$e_{i+1}$$

$$e_{i-1}$$

$$e_{i-2}$$

e_i

e_{n-1}

e_{n-2}

eds

fiber

fiber

fiber

$$f(s)$$

$$f(s)$$

$$f(s)$$

ghost

handle

$$\kappa_1 d_1$$

$$\kappa_1 d_1$$

$$\kappa_2 d_2$$

NO

κ_1

//////////

κ_2

κ_3

$$\kappa_{i+1}$$

$$\kappa_{i-1}$$

κ_i

κ_{n-1}

κ_{n-2}

κ_n

Kb

κb_0

κb_1

$$\kappa b_{2i+1}$$

κb_{2i-1}

$$\kappa b_{2i}^+$$

κb_{2i}^-

$$\kappa b_{i+1}$$

$$\kappa b_{i-1}$$

κb_i

$$\kappa b_{n-1}$$

κb_{n-2}



x_1

\overline{x}_1

x_2

$$\overline{x_3}ds$$

$$x_3 ds$$

—

2

$$n(s)$$

$$n(s)$$

P

$$p = x + X_\alpha d_\alpha + u_k d_k$$

P

φ_0^+

φ_1

$$\varphi_{i+1}$$

$$\varphi_{i-1}$$

$$\varphi_{i-1}$$

$$\varphi_i^+$$

φ_i

φ_i

φ_i

//////////

$$\frac{\varphi_i}{2}$$

$$\varphi_{n-1}$$

φ_n

φ_n

φ_n

$$r = X_\alpha d_\alpha + u_k d_k$$

$$\overline{r} = X_a \overline{d}_a$$

$$s + ds$$

$$s - ds$$

s_{i+1}

s_{i-1}

S_i

s_{n-1}

S_n

$$s_t + (1 + e)ds$$

$$s_t - (1 + e)ds$$

S_t

t_{2i+1}

$$t_{2i+2}^-$$

t_{2i-1}

$$t_{2i-2}^+$$

t_{2i}^+

t_{2i}

t_{2i}

t_{2i}

θ_z

$$u_{2i+1}$$

$$u_{2i-1}$$

$$u_{2i-2}$$

$$u_{2i-2}$$

$$u_{2i-2}$$

u_{2i}

u_{i-1}

u_i

u_{i+1}

u_i

x_0

x_1

x_2

$$x_{2i+1}$$

$$x_{2i+2}$$

x_{2i-1}

$$x_{2i-2}$$

x_{2i}

x_{i+1}

x_{i-1}

x_i

x_{n-1}

x_{n-2}

x_n

x_i^+

$\overline{x_i}$

$\overline{x_i}$

y

$$\frac{\|e_0\|}{2}$$

$$\frac{\|e_{n-1}\|}{2}$$